US009227332B2

(12) **United States Patent**
Thompson et al.

(10) **Patent No.: US 9,227,332 B2**
(45) **Date of Patent: Jan. 5, 2016**

(54) **POWER OPERATED ROTARY KNIFE**

(71) Applicant: **Bettcher Industries, Inc.**, Birmingham, OH (US)

(72) Inventors: **Terry J. Thompson**, Wakeman, OH (US); **Nicholas A. Mascari**, Wellington, OH (US); **Jeffrey A. Whited**, Amherst, OH (US)

(73) Assignee: **Bettcher Industries, Inc.**, Birmingham, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/297,118**

(22) Filed: **Jun. 5, 2014**

(65) **Prior Publication Data**

US 2014/0283393 A1 Sep. 25, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/556,008, filed on Jul. 23, 2012, now Pat. No. 8,745,881, which is a continuation-in-part of application No. 13/189,938, filed on Jul. 25, 2011, now Pat. No. 8,726,524.

(51) **Int. Cl.**

B26B 25/00	(2006.01)
A22C 17/00	(2006.01)

(52) **U.S. Cl.**
CPC ***B26B 25/002*** (2013.01); ***A22C 17/0006*** (2013.01)

(58) **Field of Classification Search**
CPC B26B 25/002; A22C 17/0006
USPC 30/347, 272.1, 276
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,220,345 A * 3/1917 Koster 384/571
1,374,988 A * 4/1921 Cooper 384/505

(Continued)

FOREIGN PATENT DOCUMENTS

DE 2906128 A1 8/1980
DE 19958802 C2 7/2001

(Continued)

OTHER PUBLICATIONS

International Search Report dated Oct. 16, 2012 and Written Opinion of the International Searching Authority dated Oct. 16, 2012 for PCT International Application No. PCT/US2012/046594, filed Jul. 13, 2012. PCT International Application No. PCT/US2012/046594 corresponds to and claims prioroty from U.S. Appl. No. 13/189,938, filed Jul. 25, 2011, issued as U.S. Pat. No. 8,726,524 on May 20, 2014. The parent application (U.S. Appl. No. 13/556,008, filed Jul. 23, 2012, issued as U.S. Pat. No. 8,745.,881 on Jun. 10, 2014) of the present application is a continuation-in-part application of U.S. Application Serial No. 189,938, filed Jul. 25, 2011. (17 pages).

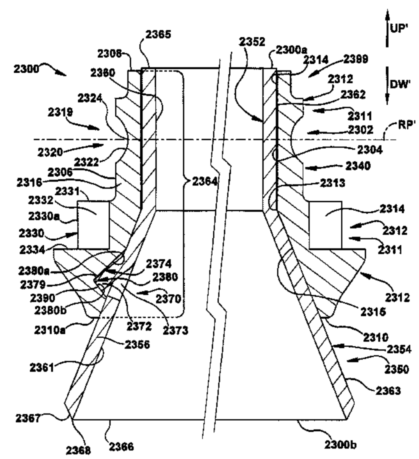
(Continued)

Primary Examiner — Sean Michalski
(74) *Attorney, Agent, or Firm* — Tarolli, Sundheim, Covell & Tummino LLP

(57) **ABSTRACT**

A two-part rotary knife blade (**2300**, **3300**) for a power operated rotary knife. The knife blade (**2300**) includes a carrier portion (**2302**, **3302**) and a blade portion (**2350**, **3350**), the blade portion configured to be received in a nested relationship by the carrier portion and being releasably secured to the carrier portion by an attachment structure (**2370**, **3370**). The attachment structure (**2370**, **3370**) including a plurality of projections (**2372**, **3372**) extending from one of an outer wall (**2354**, **3354**) of the blade portion (**2350**, **3350**) and the inner wall (**2304**, **3304**) of the carrier portion and a plurality of sockets (**2374**, **3374**) disposed in the other of the outer wall of the blade portion and the inner wall of the carrier portion, each of the plurality of projections being received in a respective different one of the plurality of sockets to releasably secure the blade portion to the carrier portion.

19 Claims, 71 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

1,476,345	A		9/1922	McGee	
2,266,888	A		12/1941	McCurdy et al.	
2,827,657	A	*	3/1958	Bettcher	452/137
3,150,409	A	*	9/1964	Wilcox	452/86
RE25,947	E		12/1965	Bettcher	
3,262,474	A	*	7/1966	Enders	408/209
3,269,010	A	*	8/1966	Bettcher	30/276
3,592,519	A	*	7/1971	Martin	384/503
3,816,875	A		6/1974	Duncan et al.	
4,019,833	A	*	4/1977	Gale	416/220 R
4,082,232	A		4/1978	Brewer	
4,170,063	A		10/1979	Bettcher	
4,178,683	A		12/1979	Bettcher	
4,198,750	A		4/1980	Bettcher	
4,236,531	A		12/1980	McCullough	
4,267,759	A		5/1981	Sullivan et al.	
4,326,361	A		4/1982	McGill	
4,363,170	A		12/1982	McCullough	
4,418,591	A	*	12/1983	Astle	82/113
4,439,924	A		4/1984	Bettcher	
4,494,311	A	*	1/1985	McCullough	30/276
4,509,261	A	*	4/1985	Bettcher	30/276
4,516,323	A	*	5/1985	Bettcher et al.	30/276
4,575,938	A	*	3/1986	McCullough	30/276
4,590,676	A		5/1986	Bettcher	
4,609,227	A		9/1986	Wild et al.	
4,637,140	A	*	1/1987	Bettcher	30/276
4,829,860	A	*	5/1989	VanderPol	82/113
4,854,046	A	*	8/1989	Decker et al.	452/149
4,865,473	A		9/1989	De Vito	
4,909,640	A		3/1990	Nakanishi	
4,942,665	A		7/1990	McCullough	
5,033,876	A		7/1991	Kraus	
5,071,264	A		12/1991	Franke et al.	
5,099,721	A		3/1992	Decker et al.	
5,230,154	A		7/1993	Decker et al.	
5,331,877	A		7/1994	Ishii	
5,419,619	A		5/1995	Lew	
5,522,142	A	*	6/1996	Whited	30/276
5,529,532	A	*	6/1996	Desrosiers	451/344
5,664,332	A	*	9/1997	Whited et al.	30/276
5,692,307	A	*	12/1997	Whited et al.	30/276
5,749,661	A		5/1998	Moller	
5,761,817	A	*	6/1998	Whited et al.	30/276
5,971,413	A		10/1999	El-Kassouf	
6,209,439	B1	*	4/2001	Repac et al.	83/858
6,247,847	B1		6/2001	Lob	
6,364,086	B1		4/2002	Blaurock	
6,604,288	B2		8/2003	Whited et al.	
6,615,494	B2		9/2003	Long et al.	
6,662,452	B2		12/2003	Whited	
6,665,940	B2		12/2003	Sanders et al.	
6,694,649	B2		2/2004	Whited et al.	
6,751,872	B1		6/2004	Whited et al.	
6,769,184	B1		8/2004	Whited	
6,857,191	B2		2/2005	Whited et al.	
6,880,249	B2		4/2005	Long et al.	
6,978,548	B2		12/2005	Whited et al.	
7,000,325	B2		2/2006	Whited	
7,107,887	B2		9/2006	Whited	
7,207,114	B2		4/2007	Rosu et al.	
7,959,419	B2	*	6/2011	Borowski et al.	417/423.15
8,074,363	B2		12/2011	Whited	
8,448,340	B2	*	5/2013	Whited	30/276
8,505,207	B2	*	8/2013	Thien	30/276
2003/0131482	A1	*	7/2003	Long et al.	30/276
2006/0137193	A1	*	6/2006	Whited	30/276
2006/0211966	A1	*	9/2006	Hatton et al.	602/16
2006/0275152	A1	*	12/2006	Borowski et al.	417/360
2007/0283573	A1	*	12/2007	Levsen	30/276
2007/0283574	A1		12/2007	Levsen	
2008/0098605	A1		5/2008	Whited et al.	
2008/0168667	A1	*	7/2008	Spinato	30/391
2009/0227192	A1		9/2009	Luthi et al.	
2011/0185580	A1		8/2011	Whited	
2011/0247220	A1		10/2011	Whited et al.	
2012/0030952	A1	*	2/2012	Levsen	30/276
2013/0025134	A1	*	1/2013	Mascari et al.	30/165
2013/0025136	A1	*	1/2013	Whited et al.	30/276
2013/0025137	A1	*	1/2013	Whited et al.	30/276
2013/0025138	A1	*	1/2013	Whited et al.	30/276
2013/0025139	A1	*	1/2013	Whited et al.	30/276
2013/0185944	A1		7/2013	Thompson et al.	
2013/0243358	A1	*	9/2013	Stork et al.	384/445

FOREIGN PATENT DOCUMENTS

FR	1216947	4/1960
WO	WO 01/41980 A1	6/2001
WO	WO 2008/107490 A1	9/2008

OTHER PUBLICATIONS

International Search Report dated Nov. 30, 2012 and Written Opinion of the International Searching Authority dated Nov. 30, 2012 for PCT International Application No. PCT/US2012/047989, filed Jul. 24, 2012. PCT International Application No. PCT/US2012/047989 corresponds to the parent application (U.S. Appl. No. 13/556,008, filed Jul. 23, 2012) of the present application. PCT International Application No. PCT/US2012/047989 claims priority from the parent application (U.S. Appl. No. 13/556,008, filed Jul. 23, 2012, issued as U.S. Pat. No. 8,745,881 on Jun. 10, 2014) of present application and from U.S. Appl. No. 13/189,951, filed Jul. 25, 2011, issued as U.S. Pat. No. 8,726,524 on May 20, 2014. (14 pages).

Oct. 3, 2011 Decision and Opinion of the United States Court of Appeals for the Federal Circuit (Appeal No. 2011-1038, -1046) regarding the case styled *Bettcher Industries, Inc.* v. *Bunzl USA, Inc. and Bunzl Processor Distribution, LLC*, Case No. 3;08 CV 2424, U.S. District Court for the Northern District of Ohio, Judge Zouhary. The Decision and Opinion relates to U.S. Pat. No. 7,000,325, owned by the assignee of the present application. (47 pages).

Catalog entitled “Ball Bearing Cages”, Publication No. WLK 100 E, Publication Date—Sep. 2004, Published by International Customized Bearings. (34 pages).

Chinese Search Report, First Office Action Form, and Text of First Office Action dated Jan. 15, 2015 and Jan. 23, 2015 for Chinese Application No. 201280046479.1 is a national phase application of PCT International Application No. PCT/US2012/047989. (14 pages).

* cited by examiner

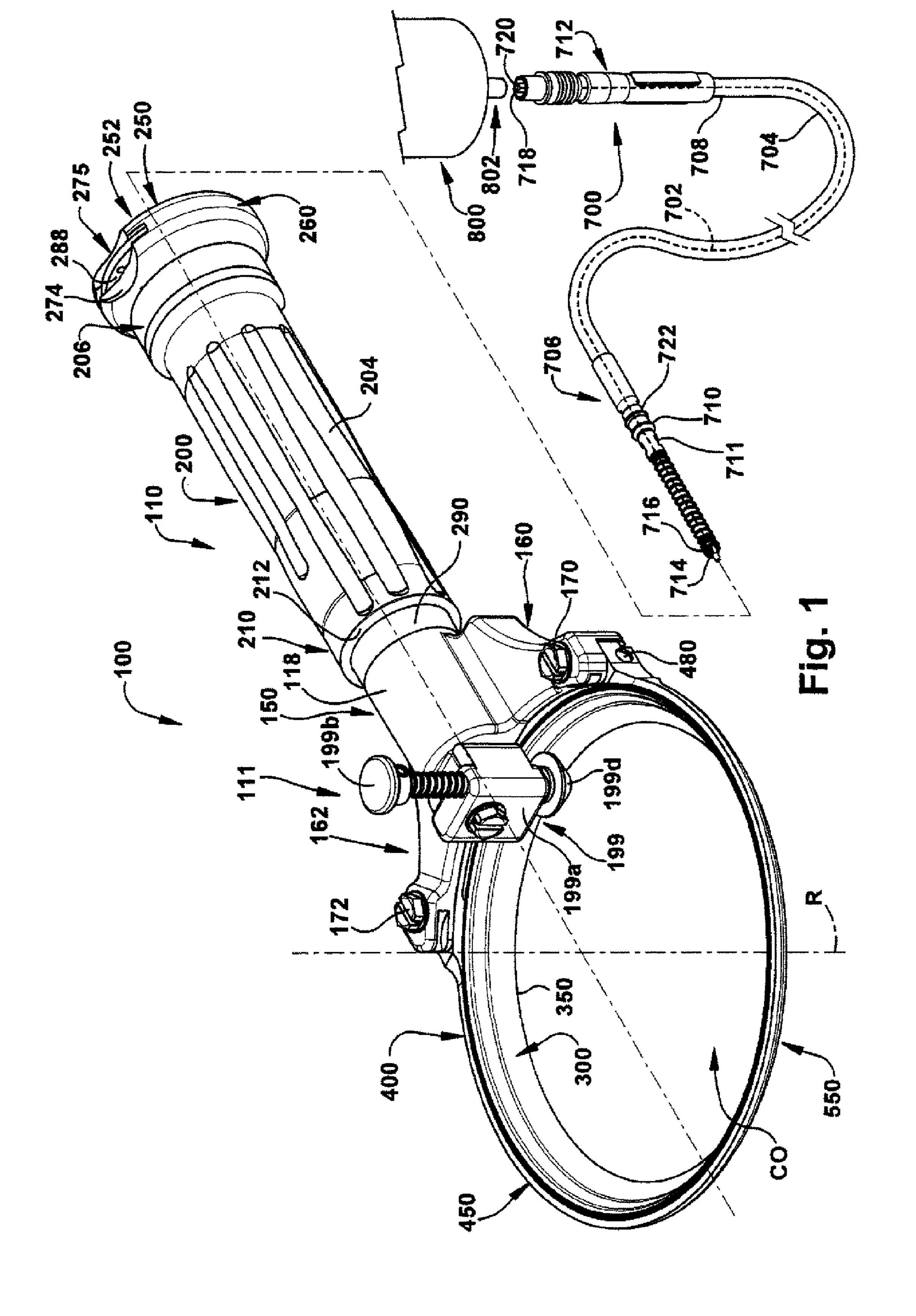

100
110
111
118
150
160
162
170
172
199
199a
199b
199d
200
204
206
210
212
250
252
260
274
275
288
290
300
350
400
450
480
550
700
702
704
706
708
710
711
712
714
716
718
720
722
800
802
R
CO

Fig. 1

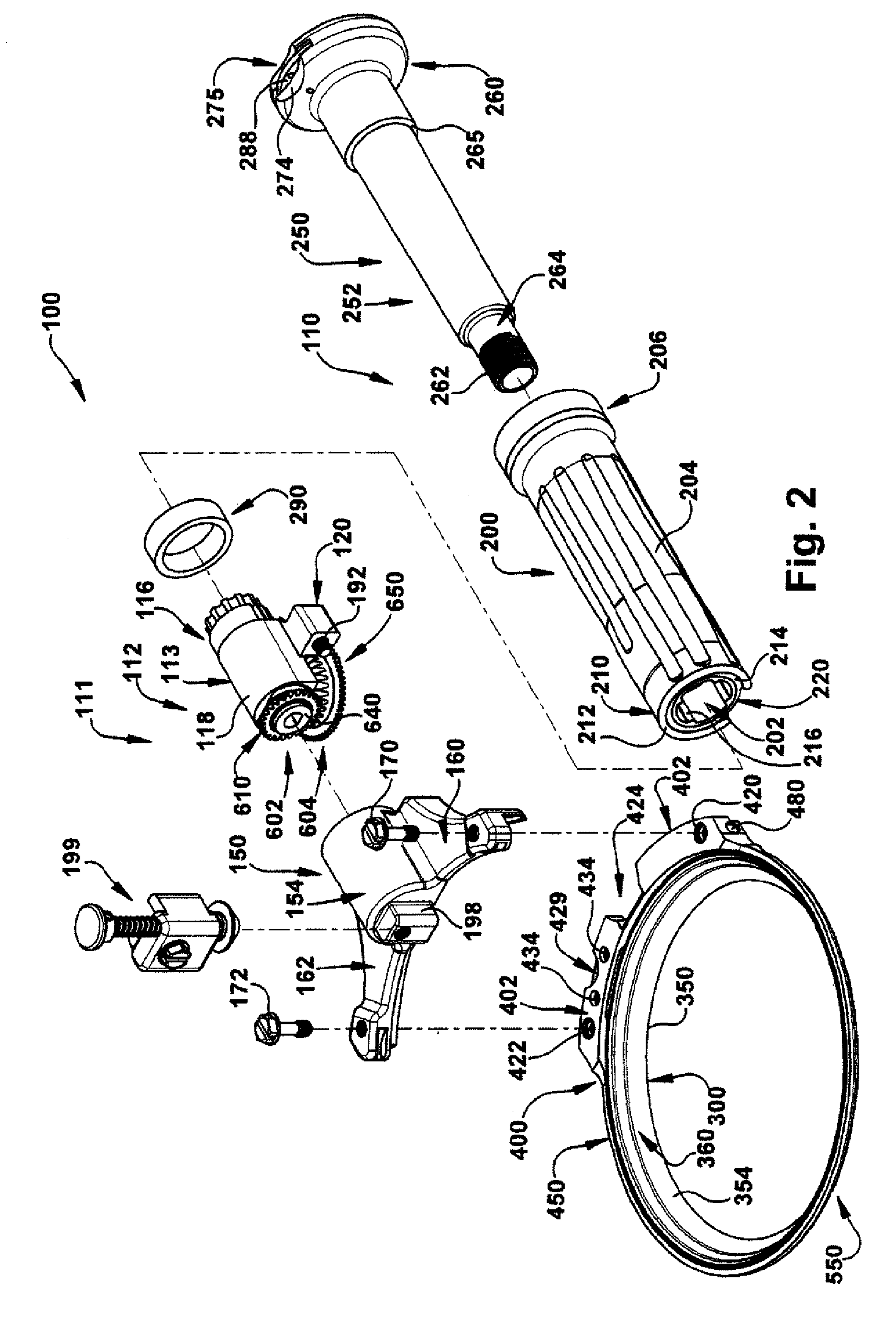

100
275
288
274
260
265
250
252
264
110
262
206
204
200
290
120
192
650
116
112
113
111
118
610
602
604
640
210
212
202
216
214
220
170
160
150
154
198
162
199
172
402
420
480
424
434
429
434
402
422
400
450
350
300
360
354
550

Fig. 2

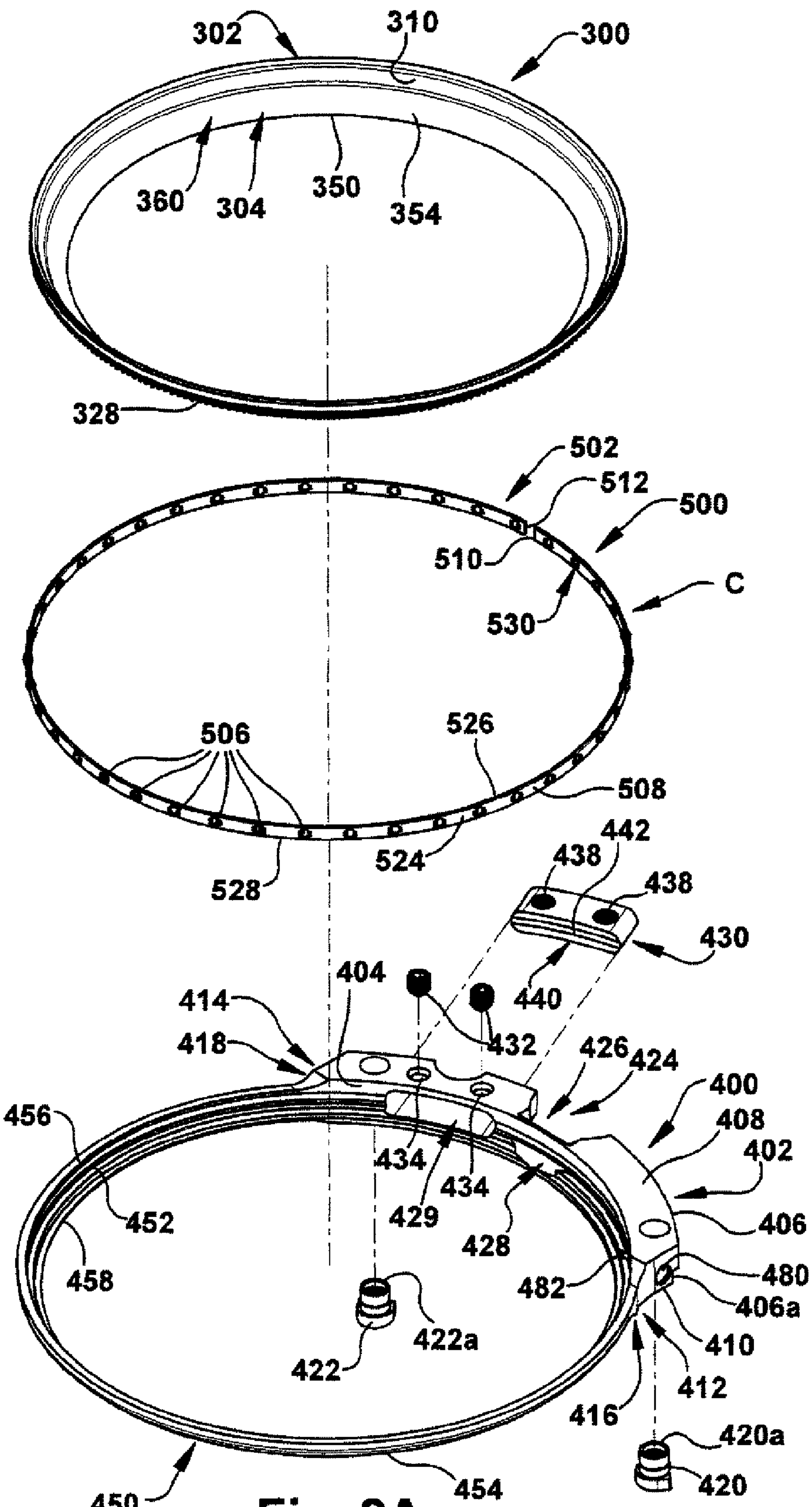

302
310
300
360
304
350
354
328
502
512
500
510
C
530
506
526
508
528
524
438
442
438
430
404
440
414
432
418
426
424
400
456
408
402
434
434
429
452
428
406
480
458
482
406a
422a
410
422
412
416
420a
450
454
420

Fig. 2A

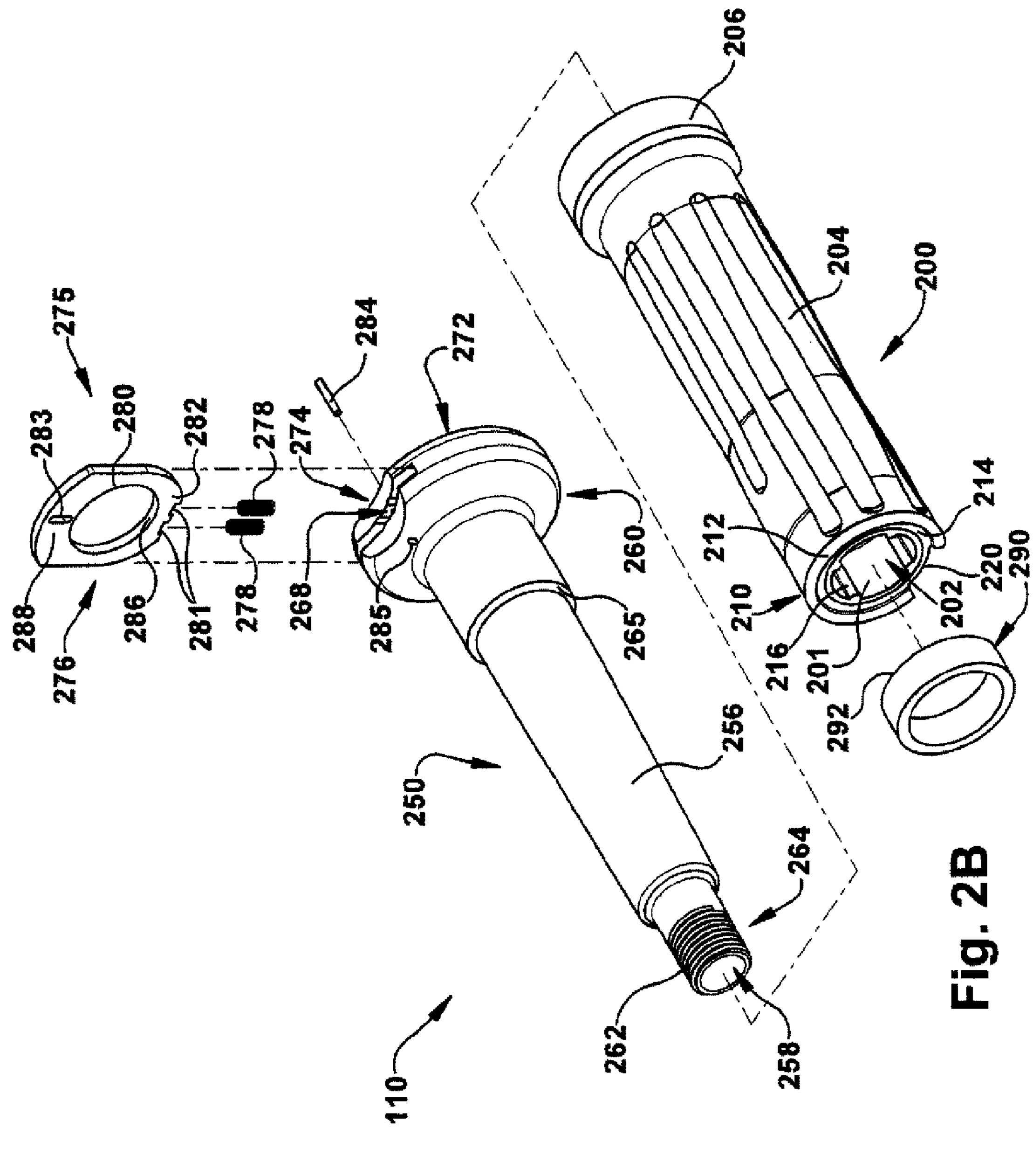

206
204
200
275
284
272
283
280
282
278
274
288
276
286
281
278
268
285
260
265
212
214
210
216
201
202
220
290
292
256
250
264
262
258
110

Fig. 2B

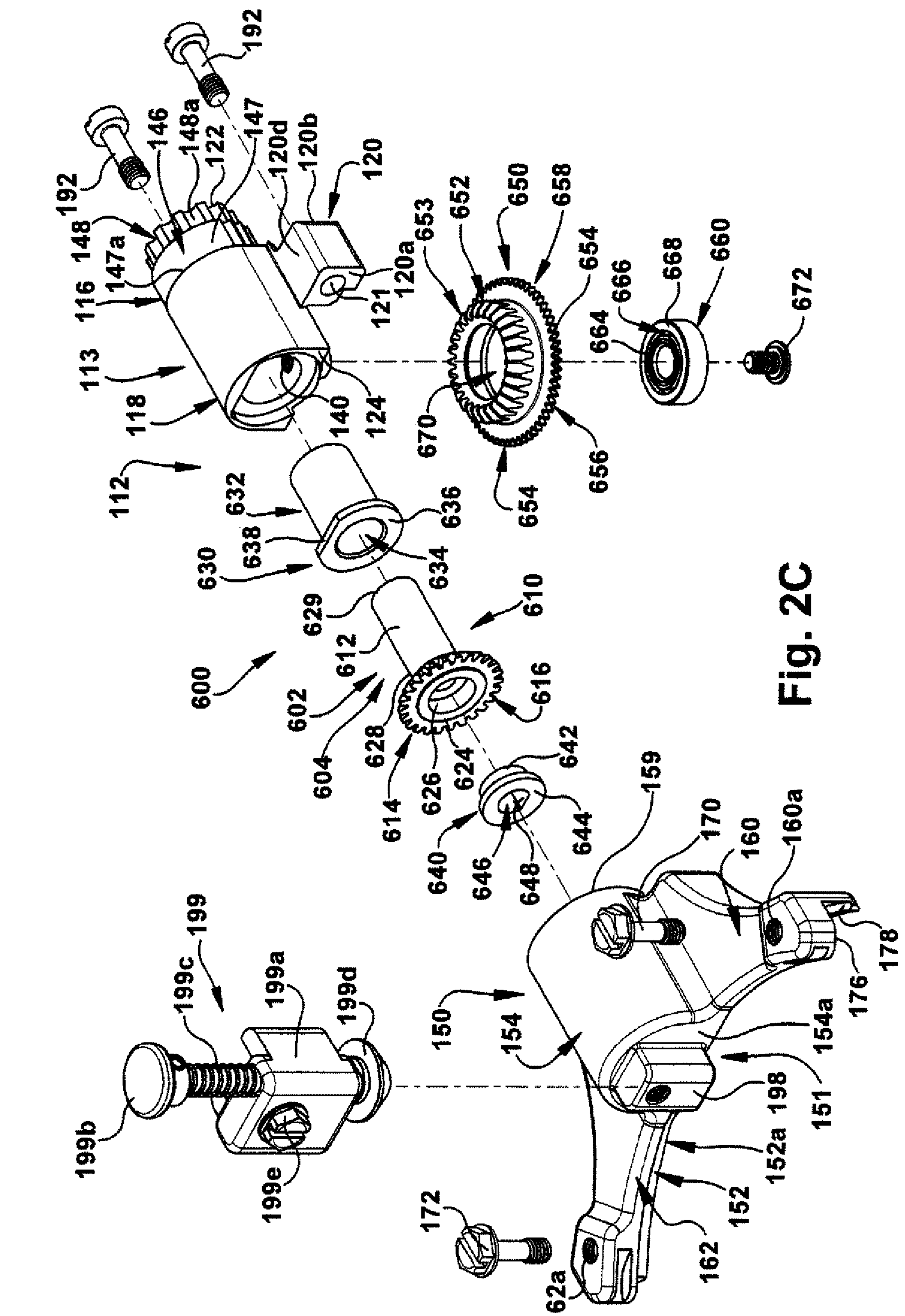
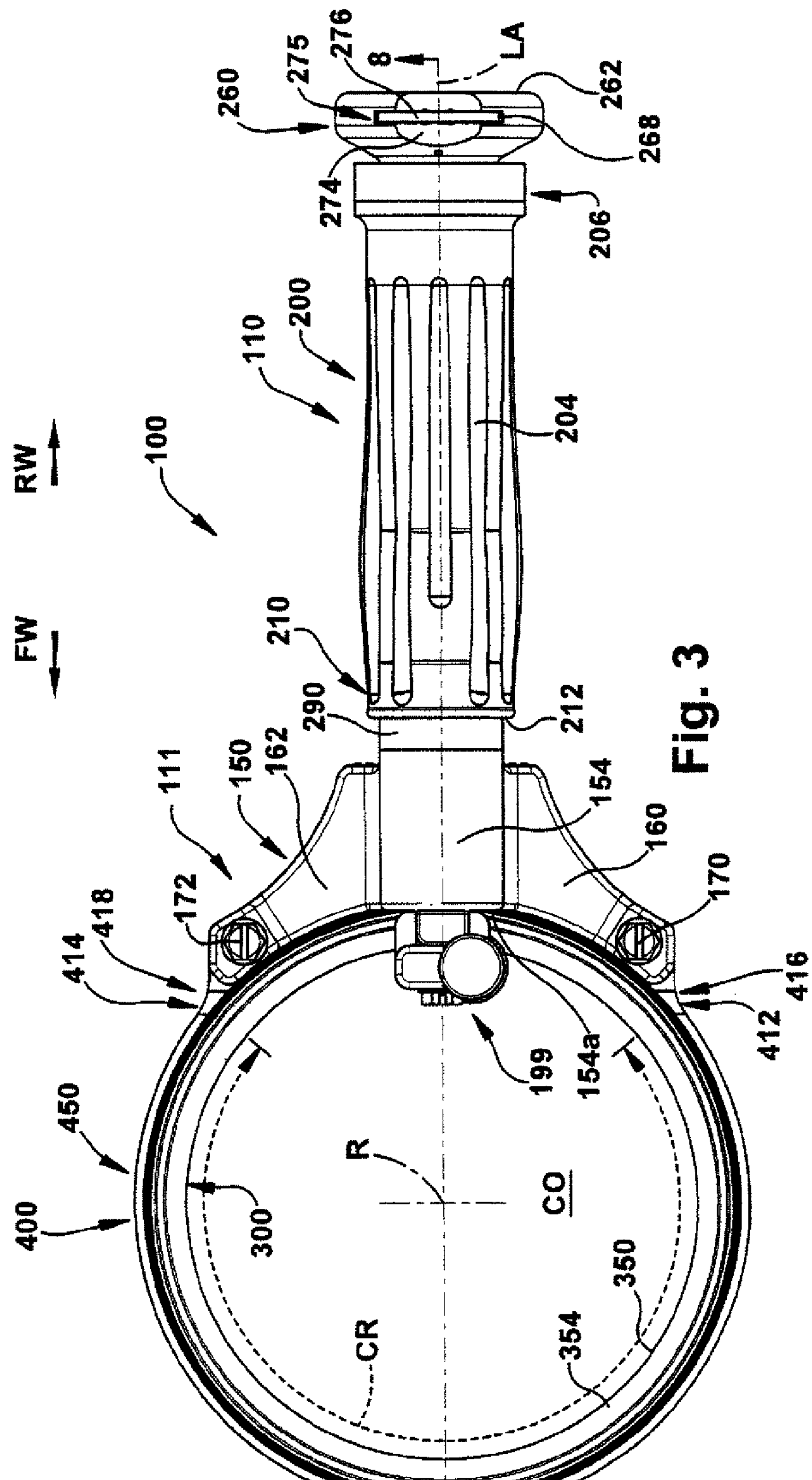

192
192
148a
146
122
147
120d
120b
120
148
147a
116
113
118
112
121
120a
124
140
653
652
650
658
654
666
668
660
664
672
670
656
654
632
636
638
634
630
600
629
612
610
602
604
628
616
614
626
624
642
640
646
648
644
159
170
160
160a
178
176
150
154
154a
151
198
152a
152
162
162a
172
199
199c
199a
199d
199b
199e

Fig. 2C



100
110
111
150
154
154a
160
162
170
172
199
200
204
206
210
212
260
262
268
274
275
276
290
300
350
354
400
412
414
416
418
450
LA
RW
FW
R
CO
CR
8
8

Fig. 3

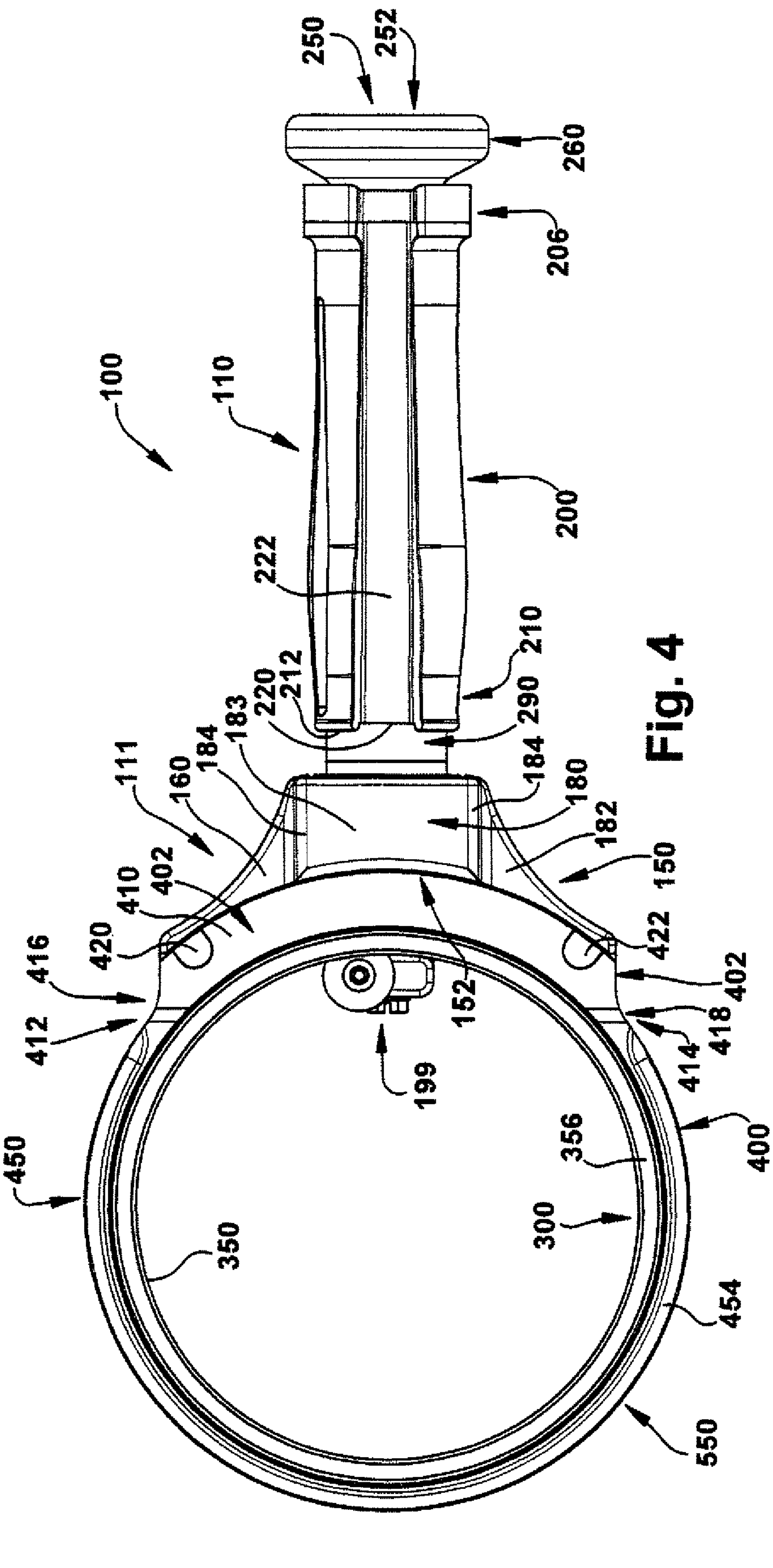

250
252
260
206
100
110
200
222
210
290
220
212
183
184
111
160
184
180
182
150
402
410
420
416
412
422
402
152
418
414
199
450
356
400
300
350
454
550

Fig. 4

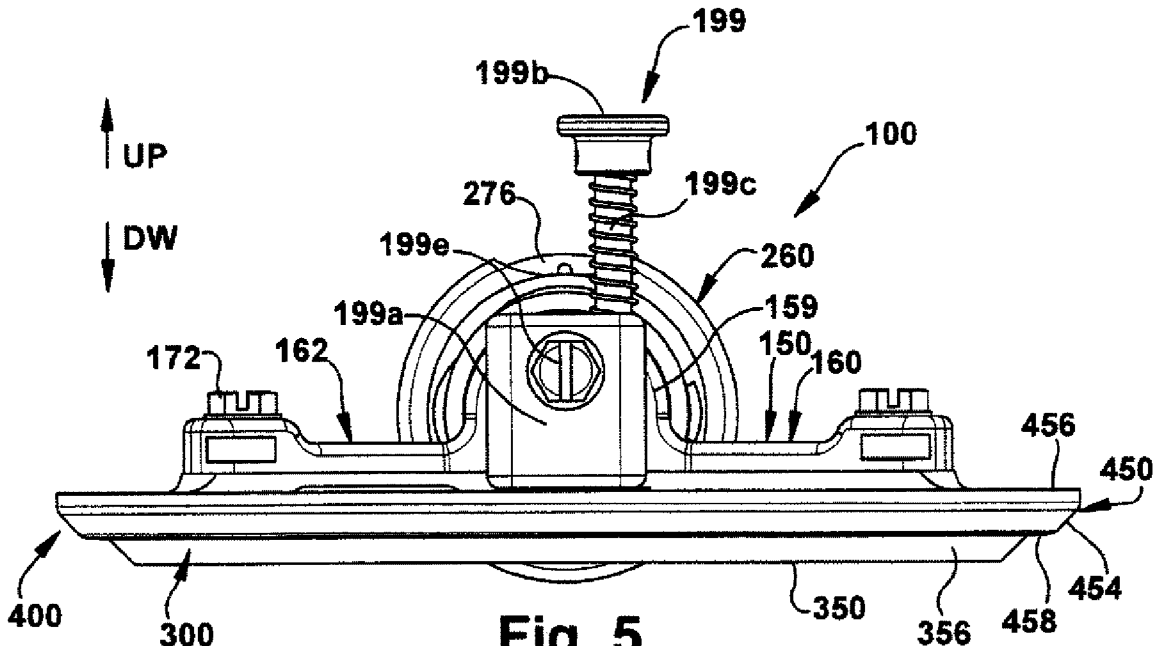

199
199b
UP
DW
100
276
199c
199e
260
199a
159
172
162
150
160
456
450
400
300
350
356
458
454

Fig. 5

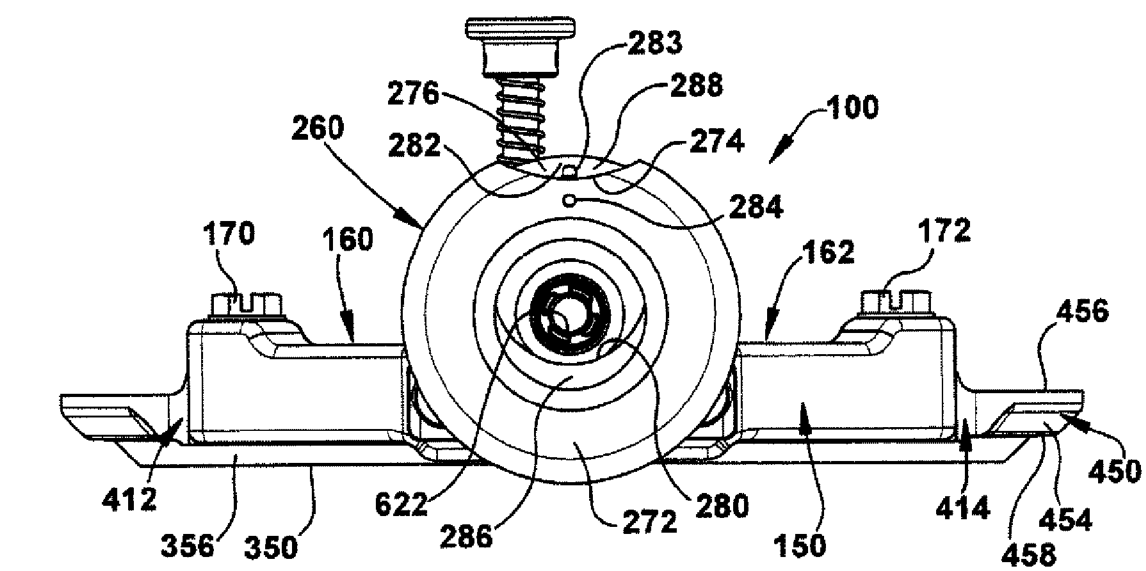

283
288
276
100
260
282
274
284
170
160
172
162
456
412
622
286
272
280
150
414
450
454
458
356
350

Fig. 6

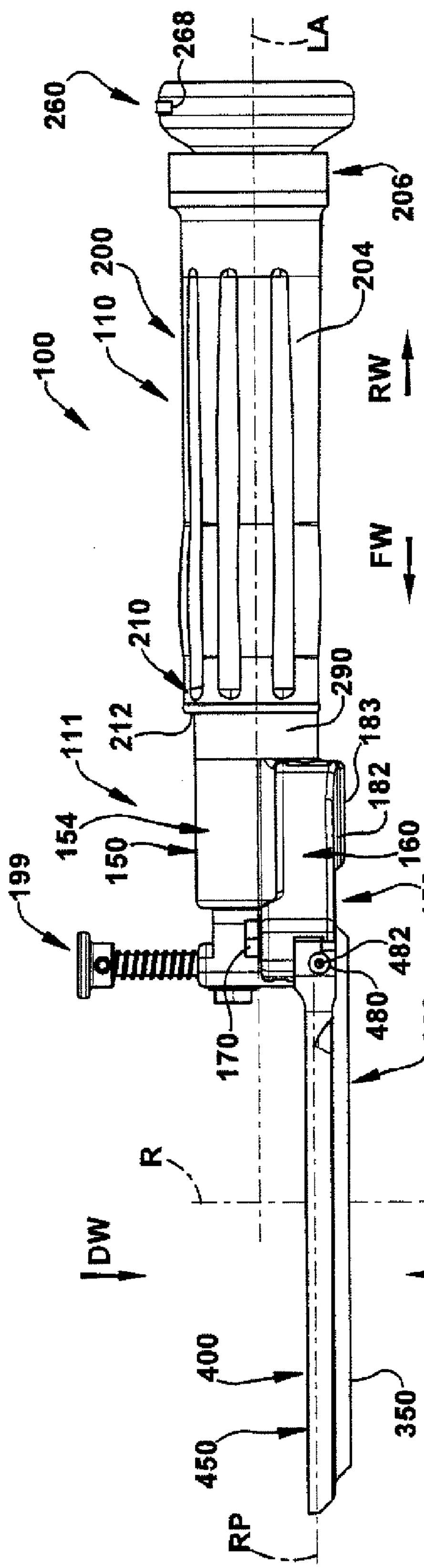

268
LA
260
206
100
110
200
204
RW
FW
210
212
290
183
182
111
154
150
160
150
199
482
480
170
300
R
DW
UP
400
450
350
RP

Fig. 7

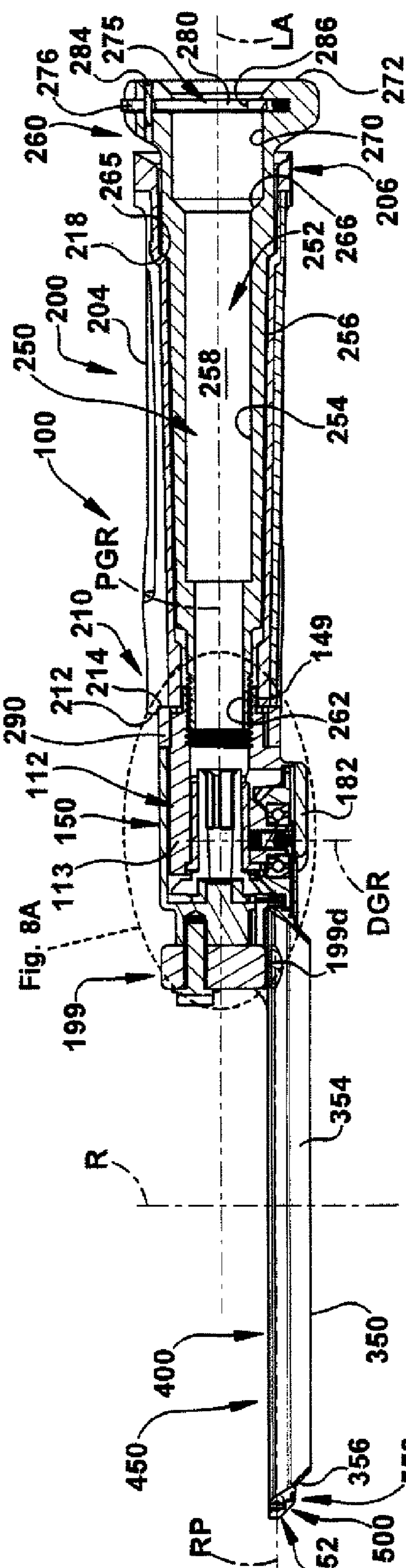

276
284
275
280
LA
286
272
260
270
206
265
266
218
252
200
204
256
250
258
254
100
PGR
210
214
212
149
262
290
112
150
182
113
DGR
Fig. 8A
199d
199
354
R
350
400
450
356
550
500
RP
552

Fig. 8

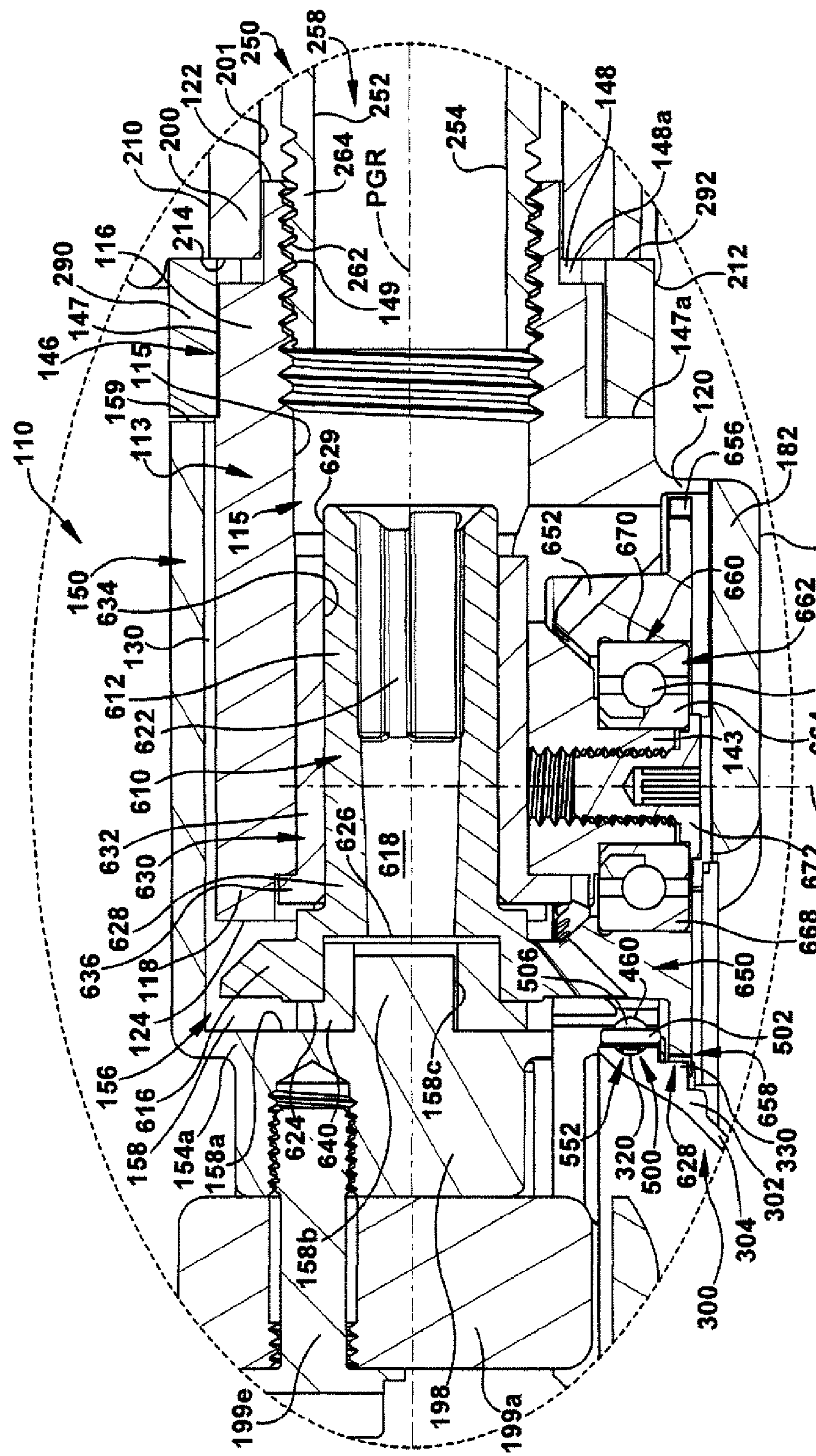

110
150
113
115
159
146
147
290
116
214
210
200
122
201
250
258
252
264
PGR
254
262
149
148
148a
292
212
147a
120
656
182
183
629
652
670
660
662
666
664
143
634
130
612
622
610
626
618
632
630
628
636
118
124
156
616
158
154a
158a
624
640
158c
158b
198
199a
199e
506
460
650
668
672
DGR
502
658
330
302
304
300
552
320
500
628

Fig. 8A

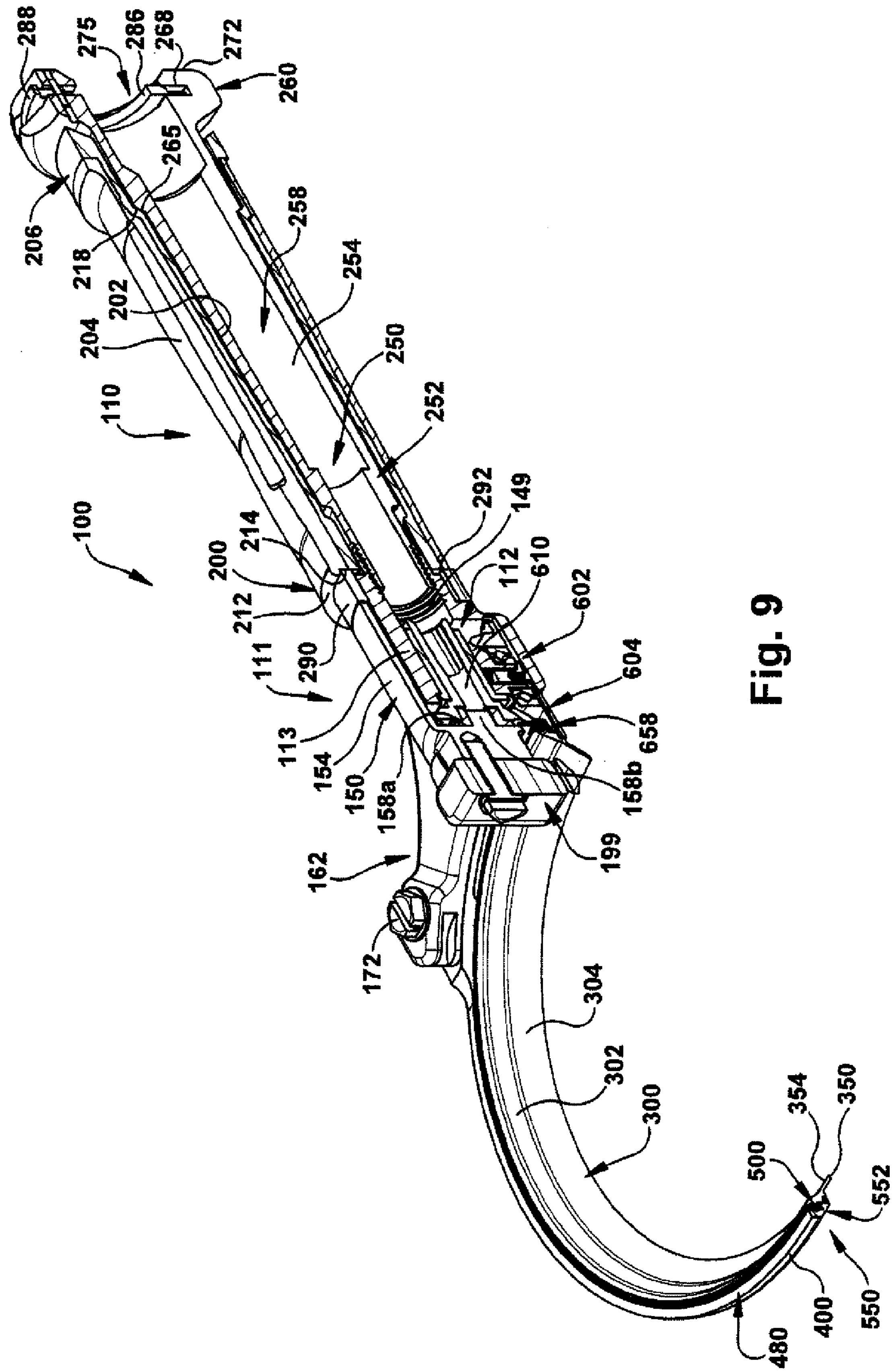

288
275
286
268
272
260
206
265
218
258
202
254
204
250
110
252
100
292
149
200
214
112
610
212
602
290
111
604
113
154
658
150
158b
158a
199
162
172
304
302
300
354
350
500
552
550
400
480

Fig. 9

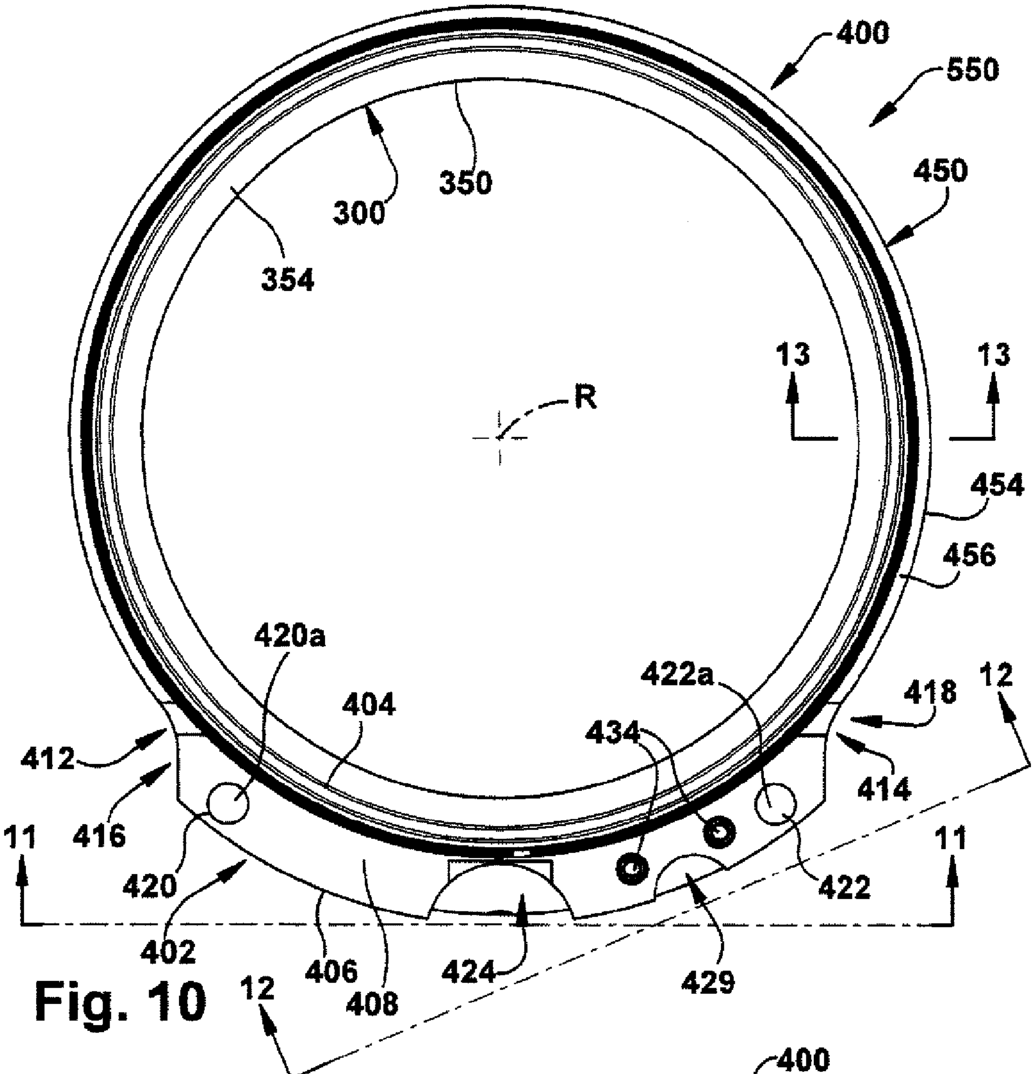


Fig. 10

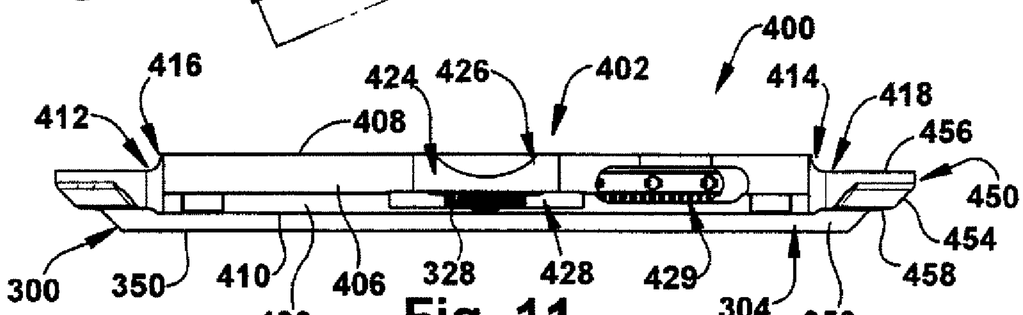


Fig. 11

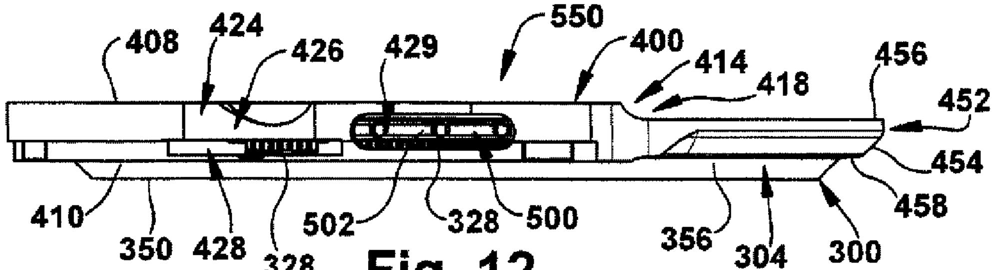


Fig. 12

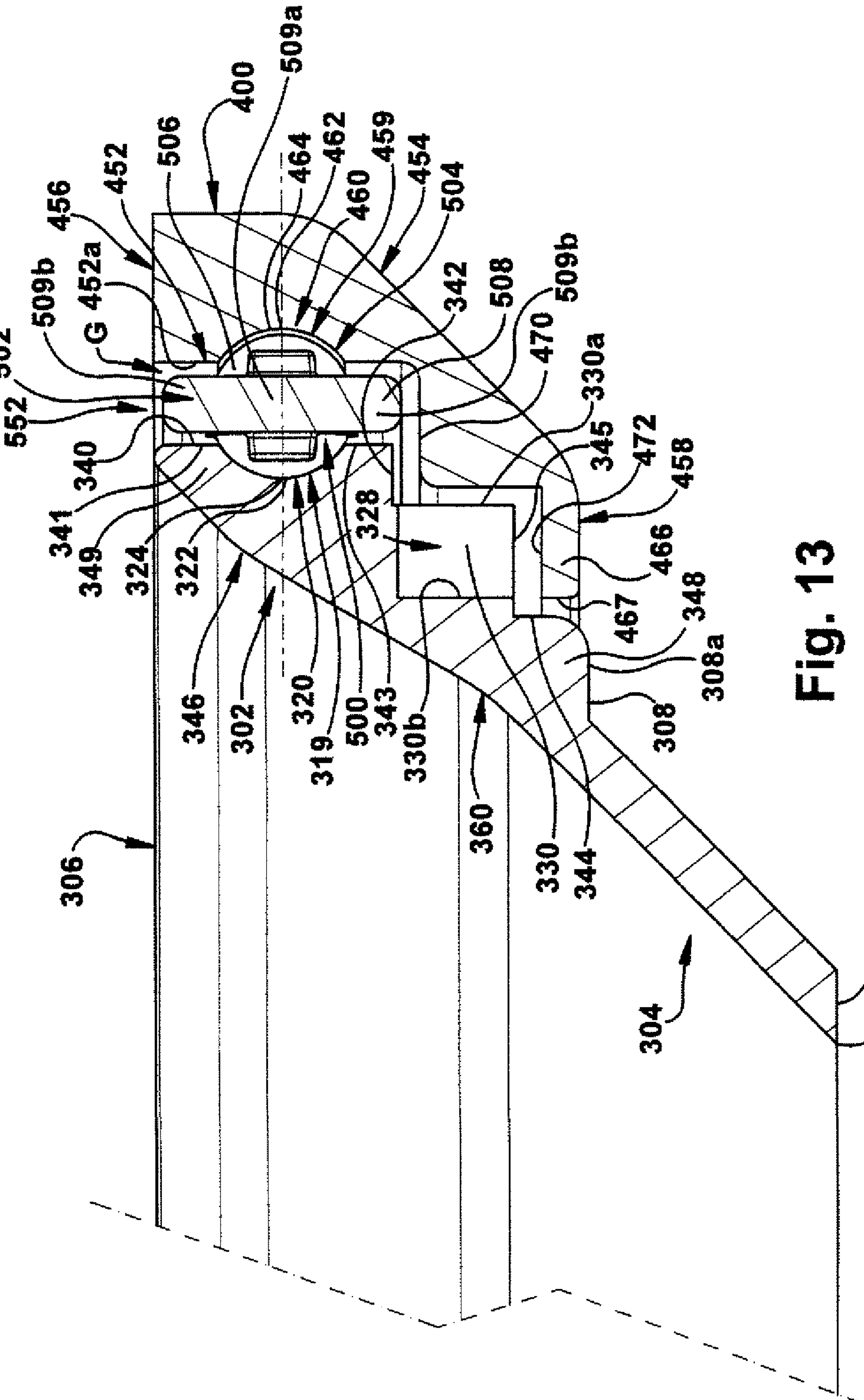

400
509a
506
464
462
459
454
504
460
456
452
509b
452a
G
502
552
340
341
349
324
322
342
508
509b
470
330a
345
472
458
466
467
348
308a
308
328
346
302
320
319
500
343
330b
360
330
344
306
304
358
350

Fig. 13

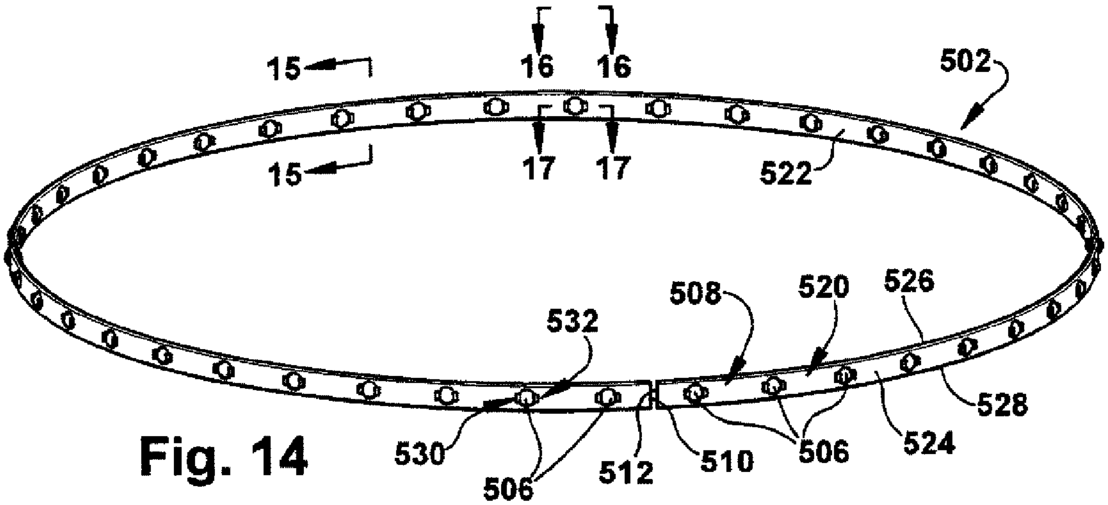


Fig. 14

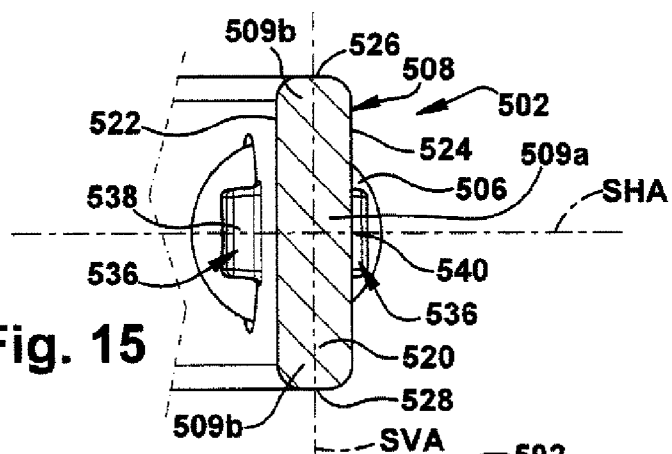


Fig. 15

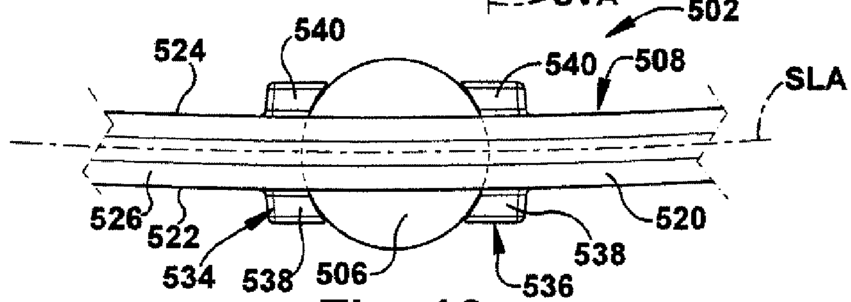


Fig. 16

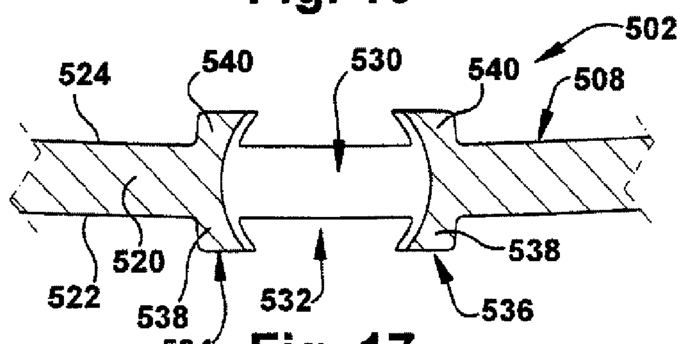


Fig. 17

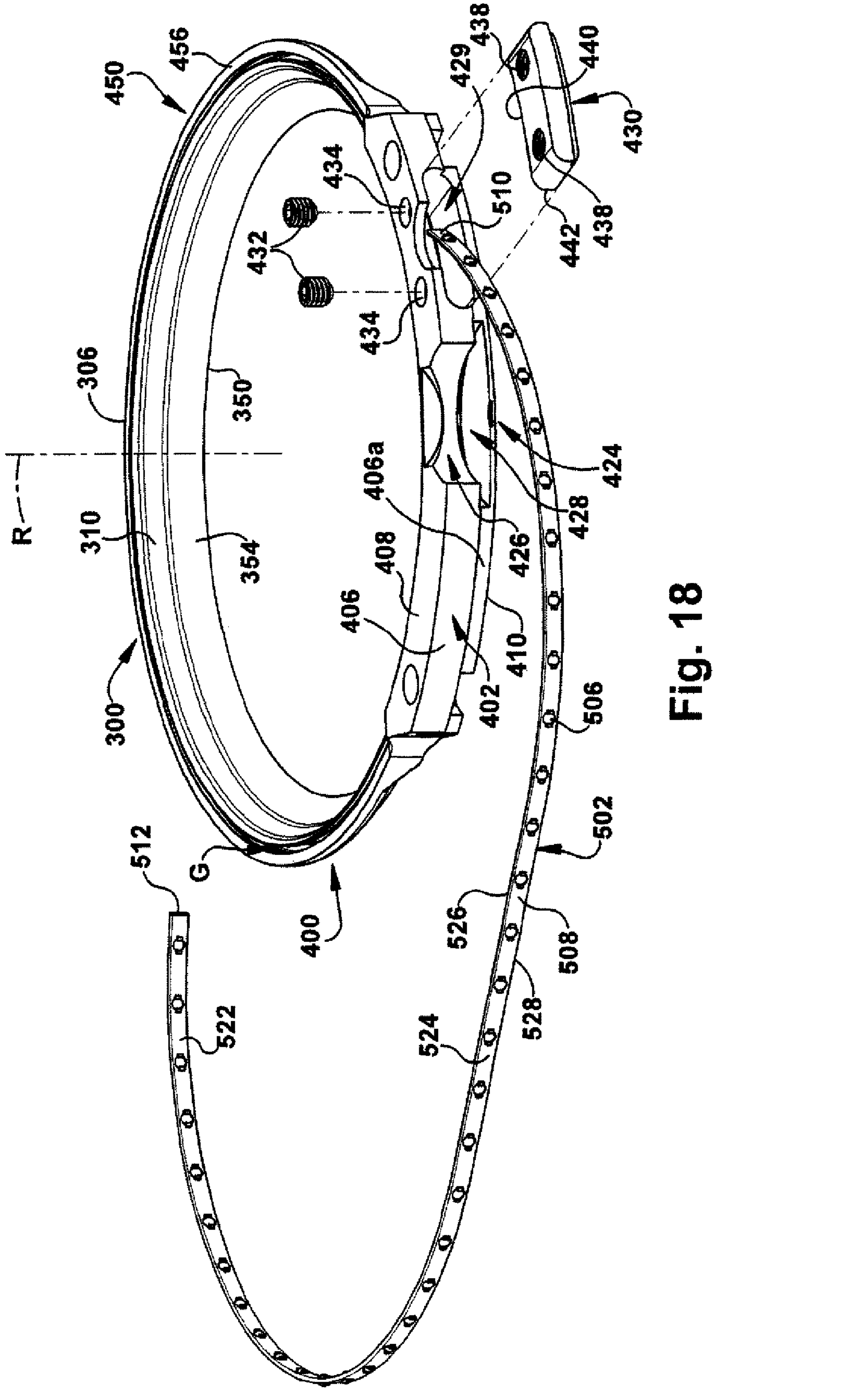

450
456
438
429
440
430
434
510
438
442
438
432
434
306
350
424
406a
428
426
R
310
354
408
406
410
402
300
506
502
512
G
400
526
508
528
522
524

Fig. 18

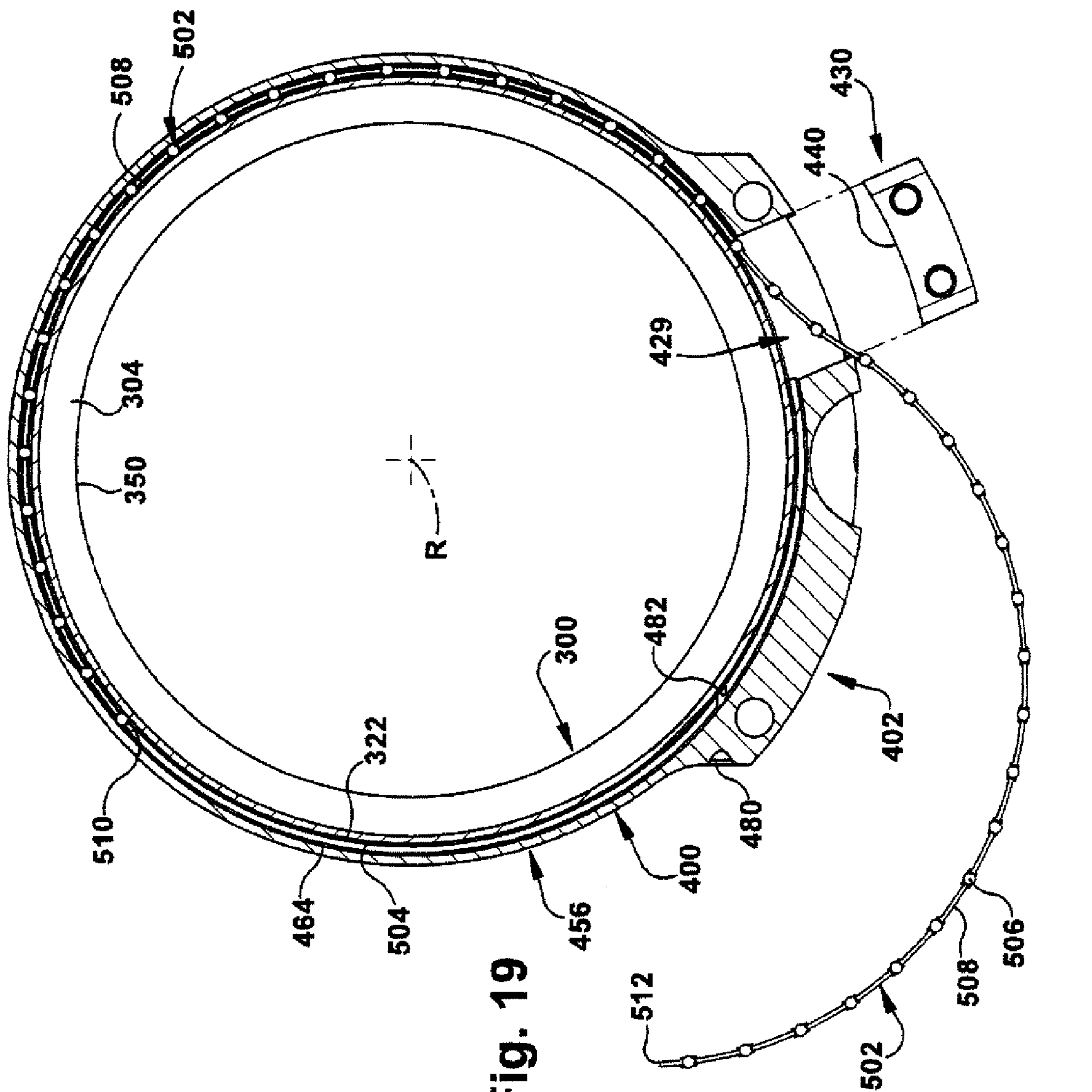

502
508
430
440
429
304
350
R
300
482
402
322
510
464
504
456
400
480
506
508
502
512

Fig. 19

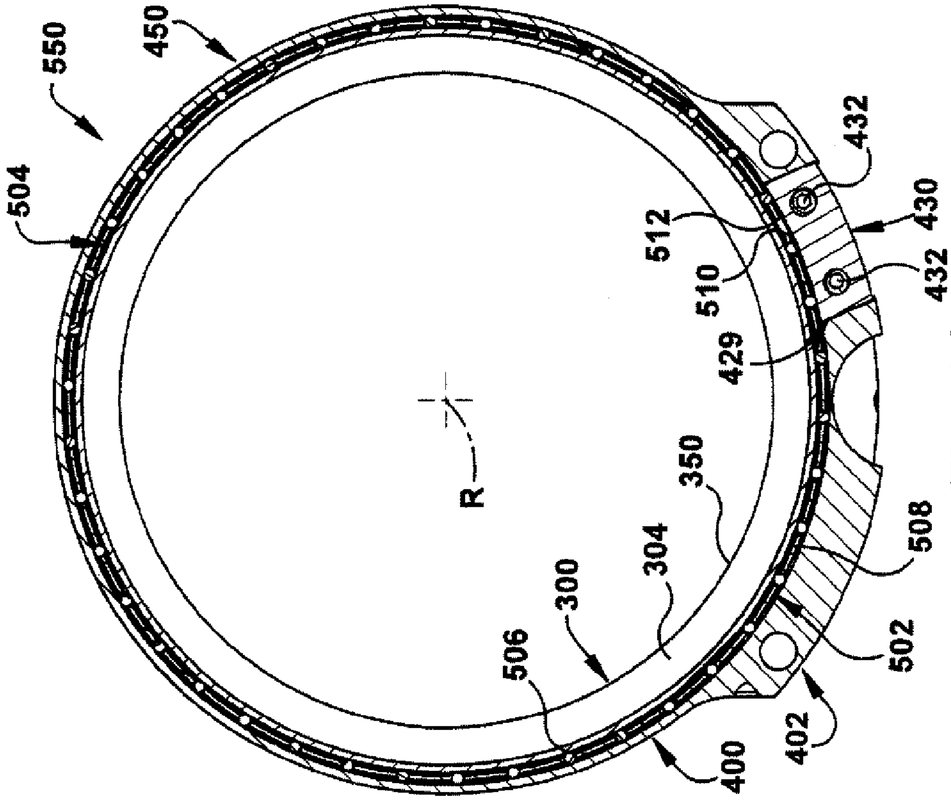

550
450
504
512
510
429
432
430
432
R
350
304
300
506
508
502
400
402

Fig. 21

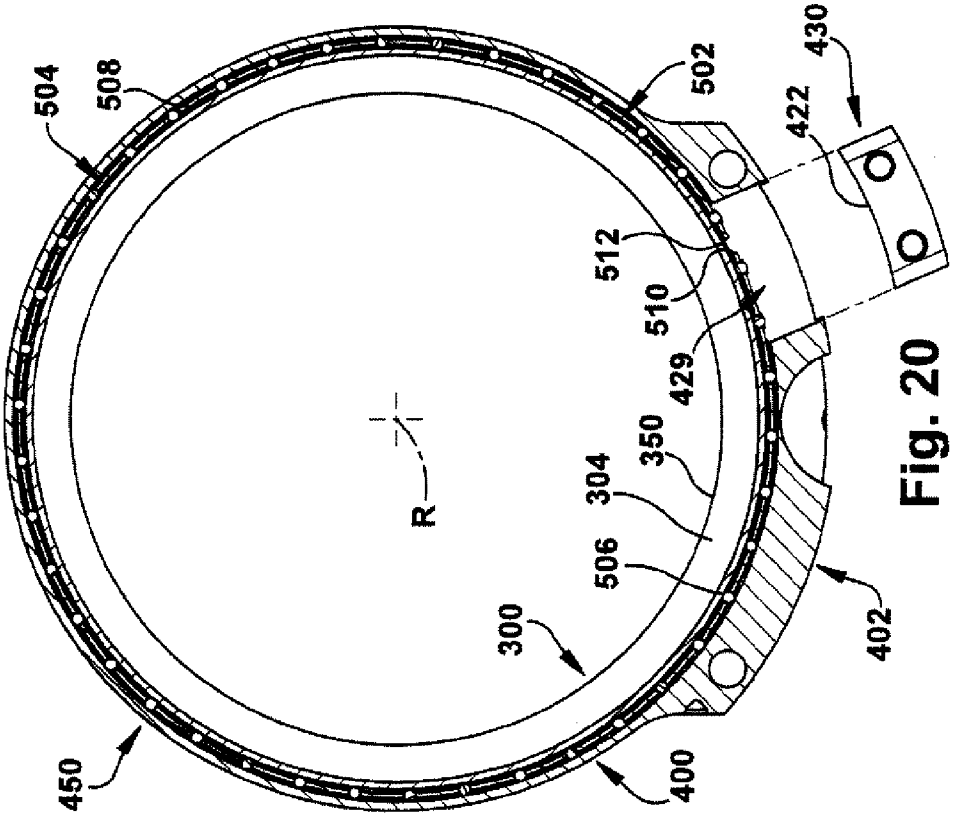

504
508
502
430
422
512
510
429
R
350
304
506
300
402
450
400

Fig. 20

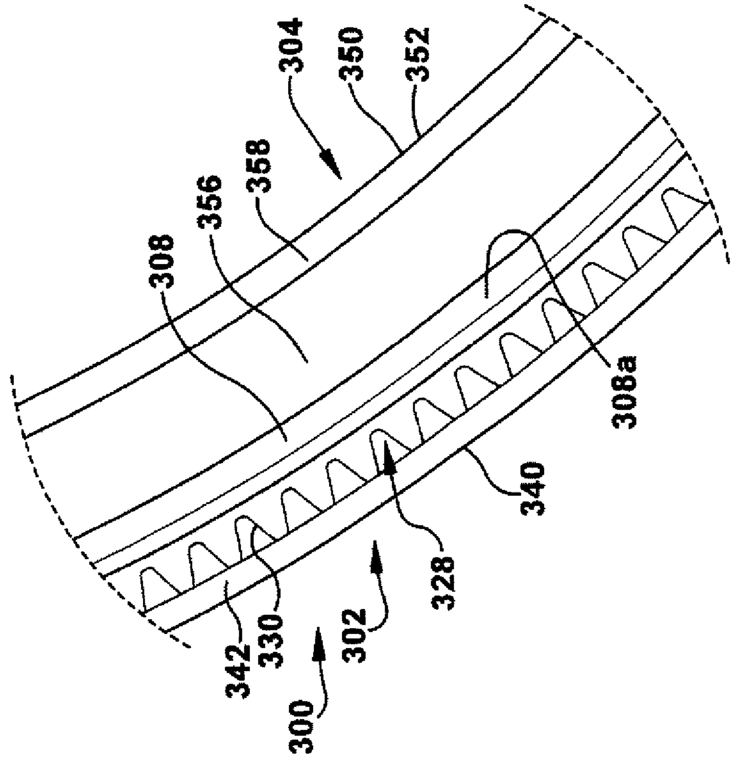

304
350
352
358
356
308
308a
340
328
302
330
342
300

Fig. 23

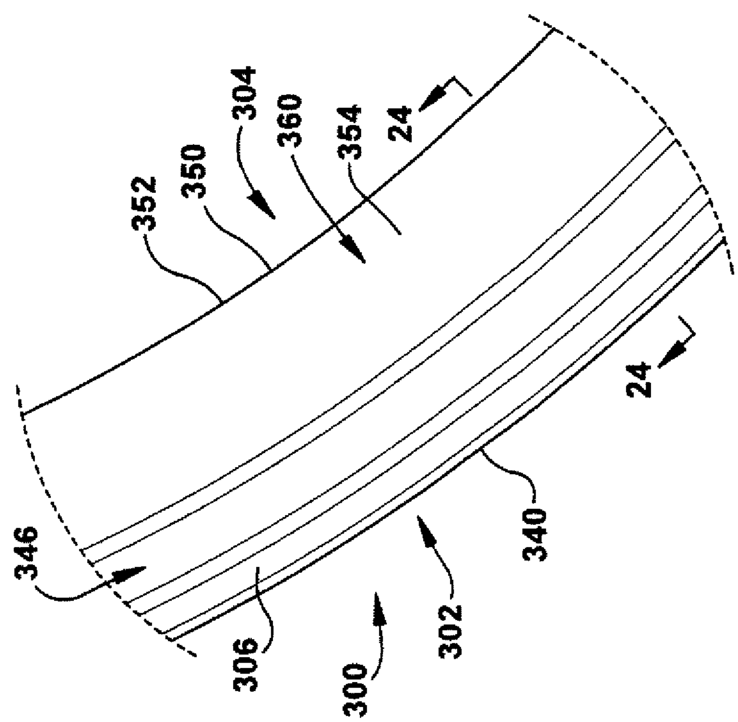

352
350
304
360
354
24
24
346
340
302
306
300

Fig. 22

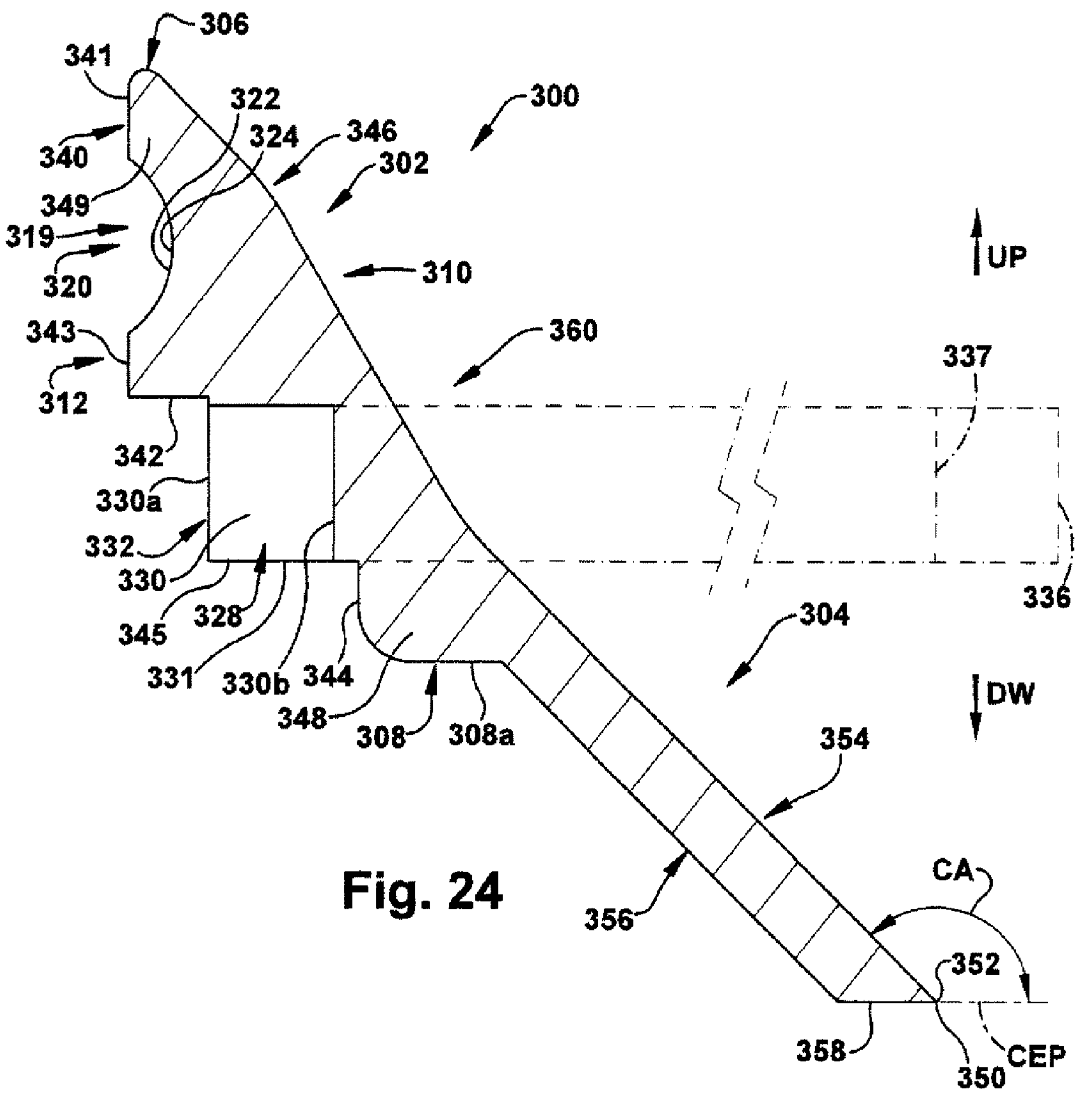

306
341
300
322
324
346
302
340
349
319
320
310
UP
343
360
312
337
342
330a
332
330
336
345
328
304
331
330b
344
348
308
308a
DW
354
356
CA
352
358
350
CEP

Fig. 24

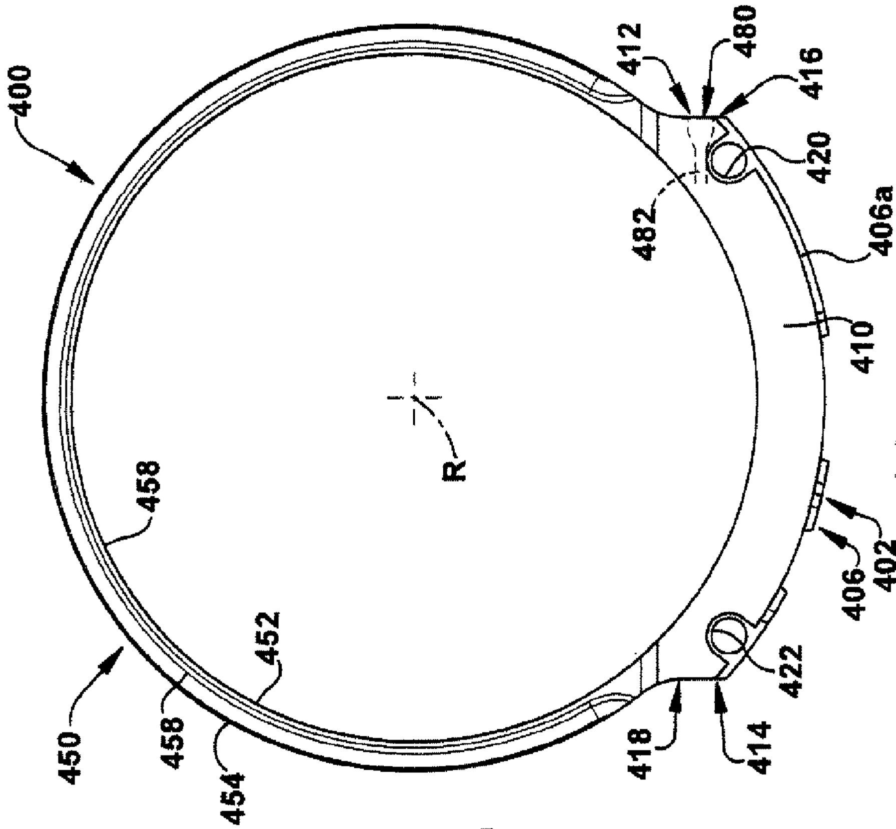

400
412
480
416
420
482
406a
410
R
458
402
406
422
452
450
458
454
418
414

Fig. 26

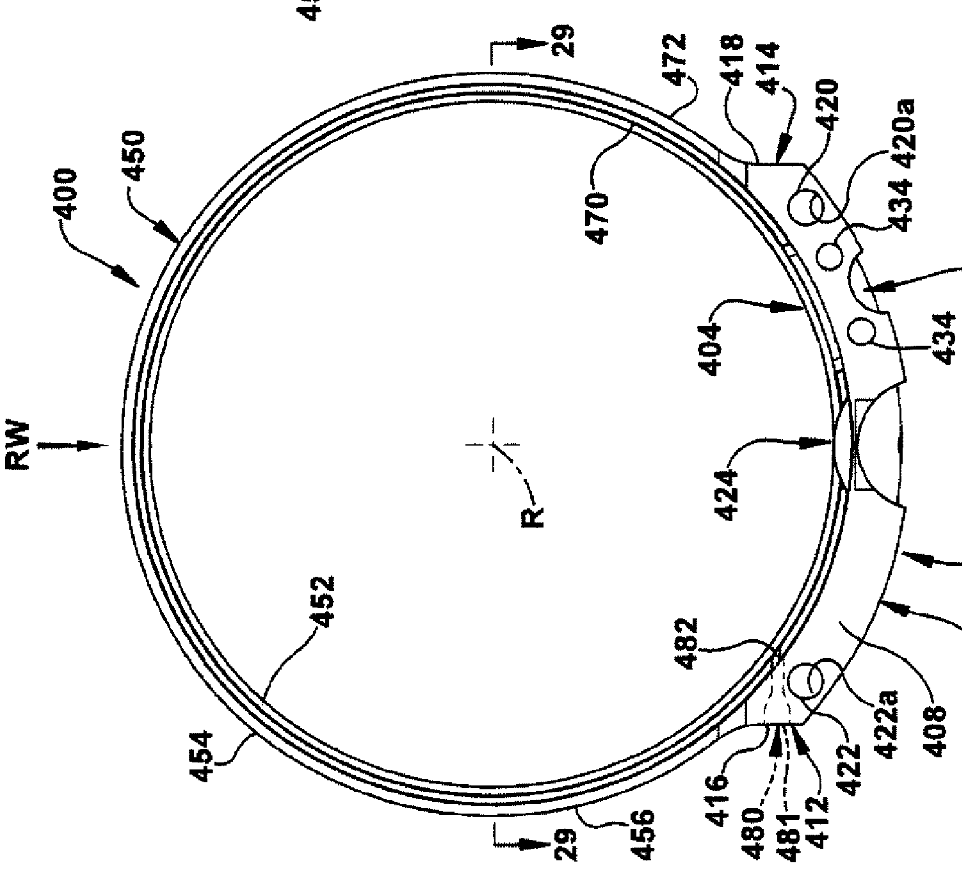

29
472
418
414
420
420a
400
450
470
434
429
404
434
RW
424
R
452
482
402
406
454
408
422a
422
416
480
481
412
456
29

Fig. 25

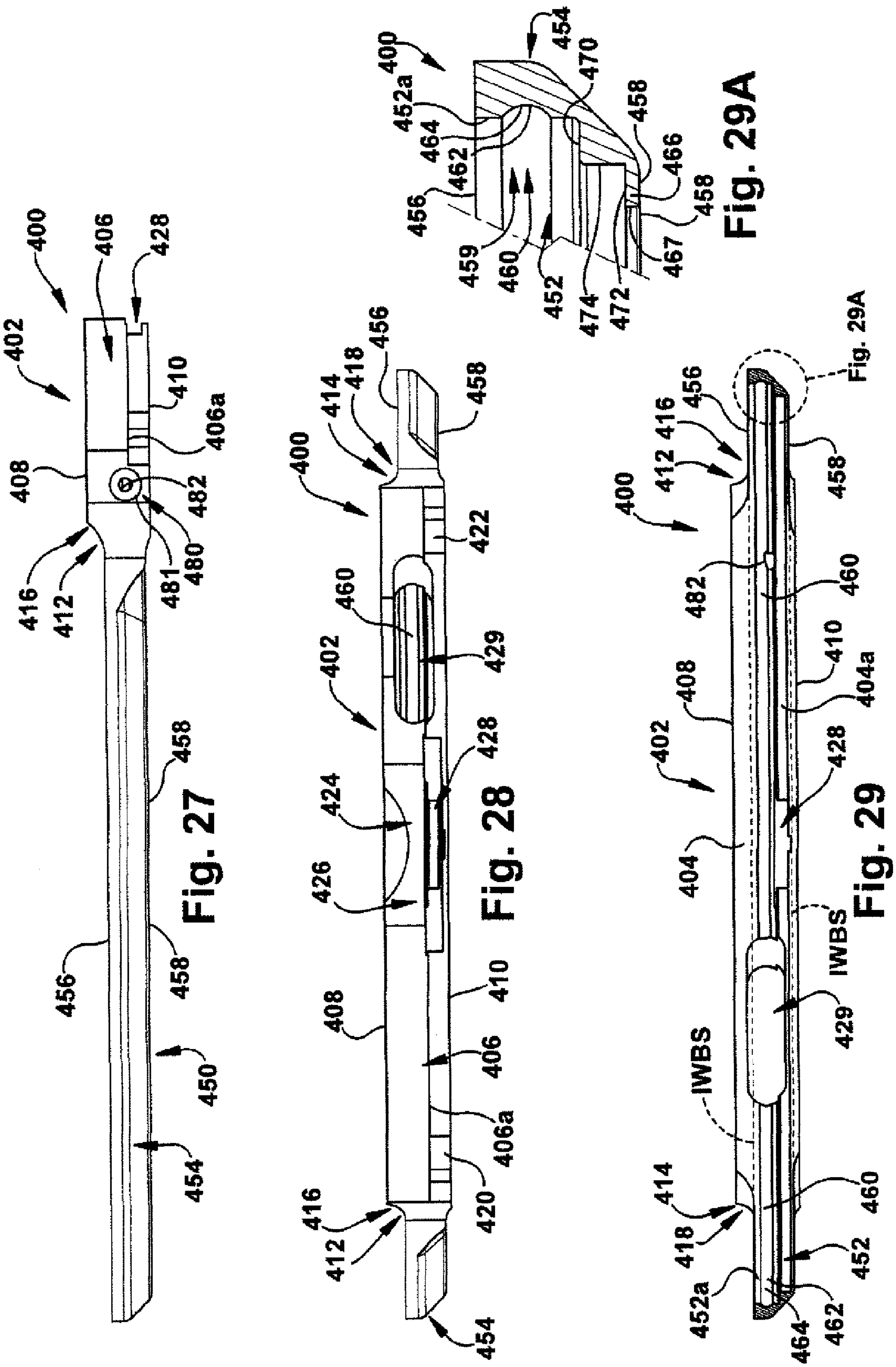


Fig. 27

Fig. 28

Fig. 29

Fig. 29A

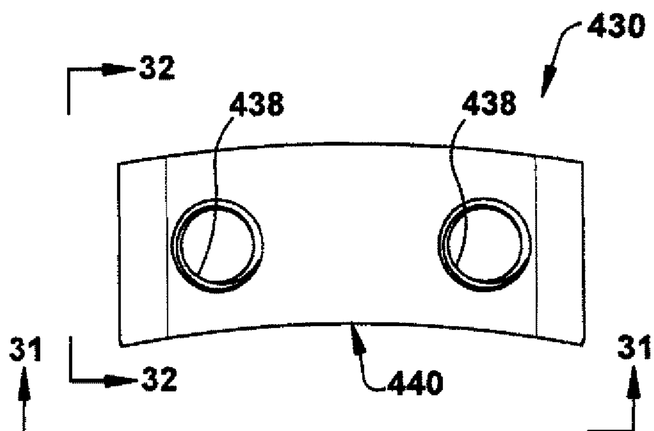


Fig. 30

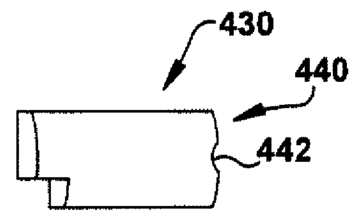


Fig. 32

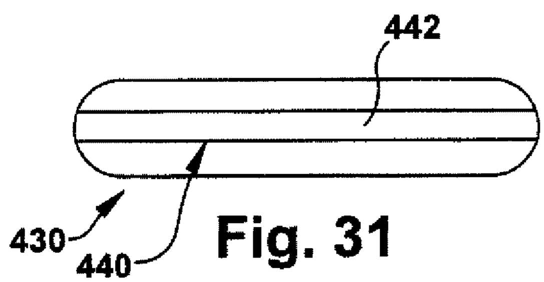


Fig. 31

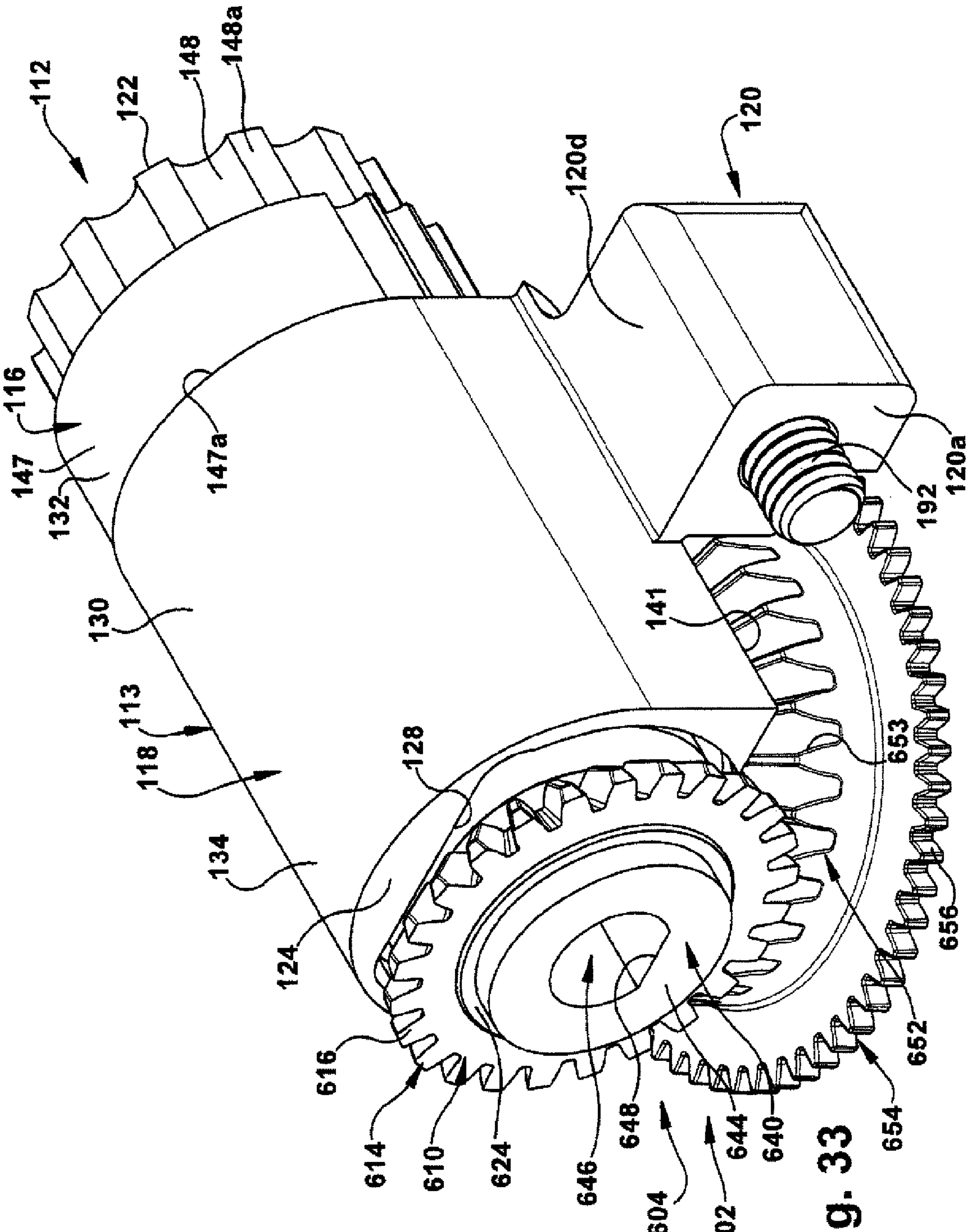

112
122
148
148a
120
120d
116
147
132
147a
120a
192
130
141
113
118
128
653
134
656
124
652
616
614
610
624
646
648
604
602
644
640
654

Fig. 33

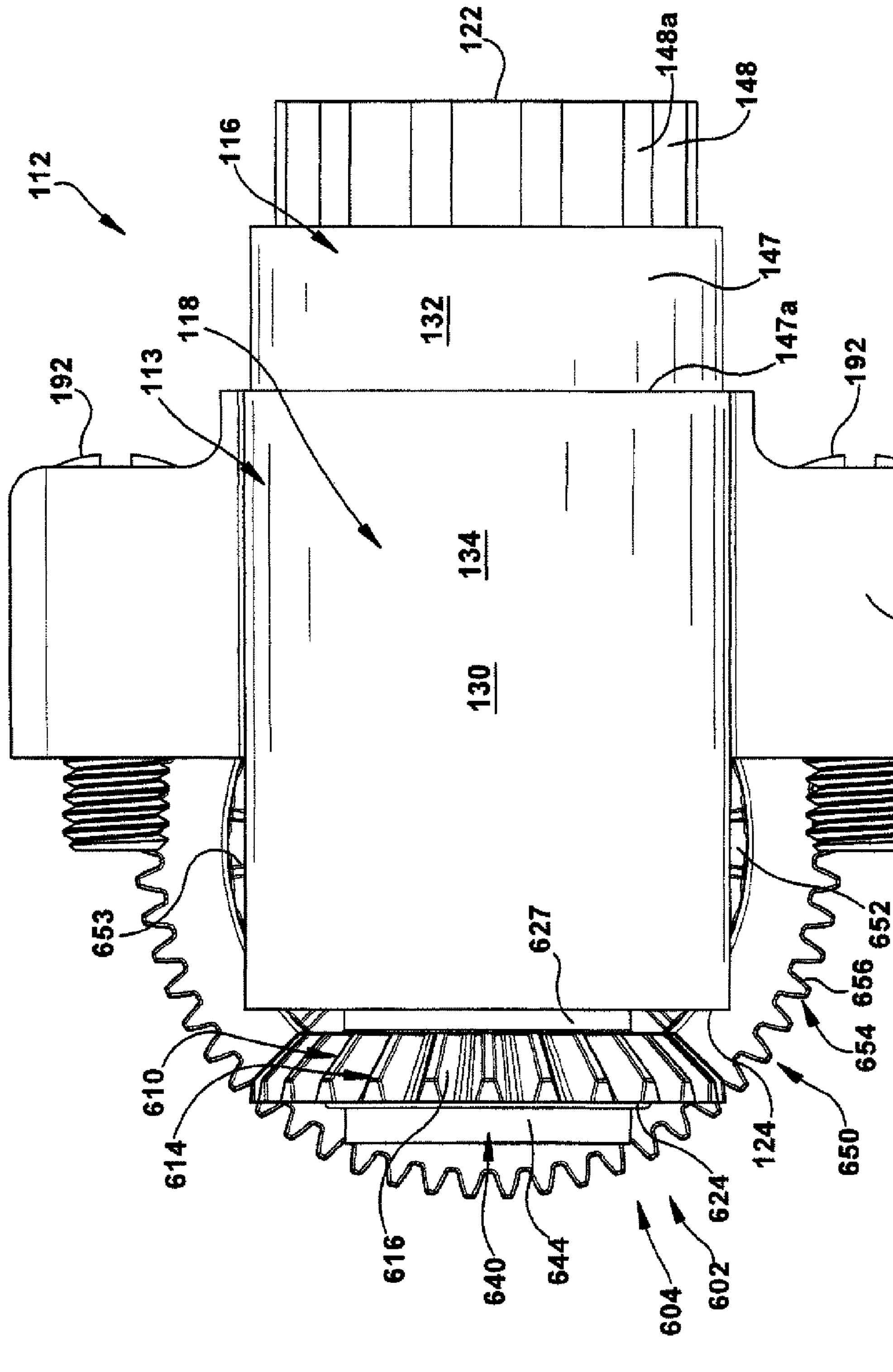

112
116
122
148a
148
147
147a
132
118
113
192
192
120b
120
134
130
120d
120a
653
652
627
656
654
650
610
614
124
616
640
644
624
604
602

Fig. 34

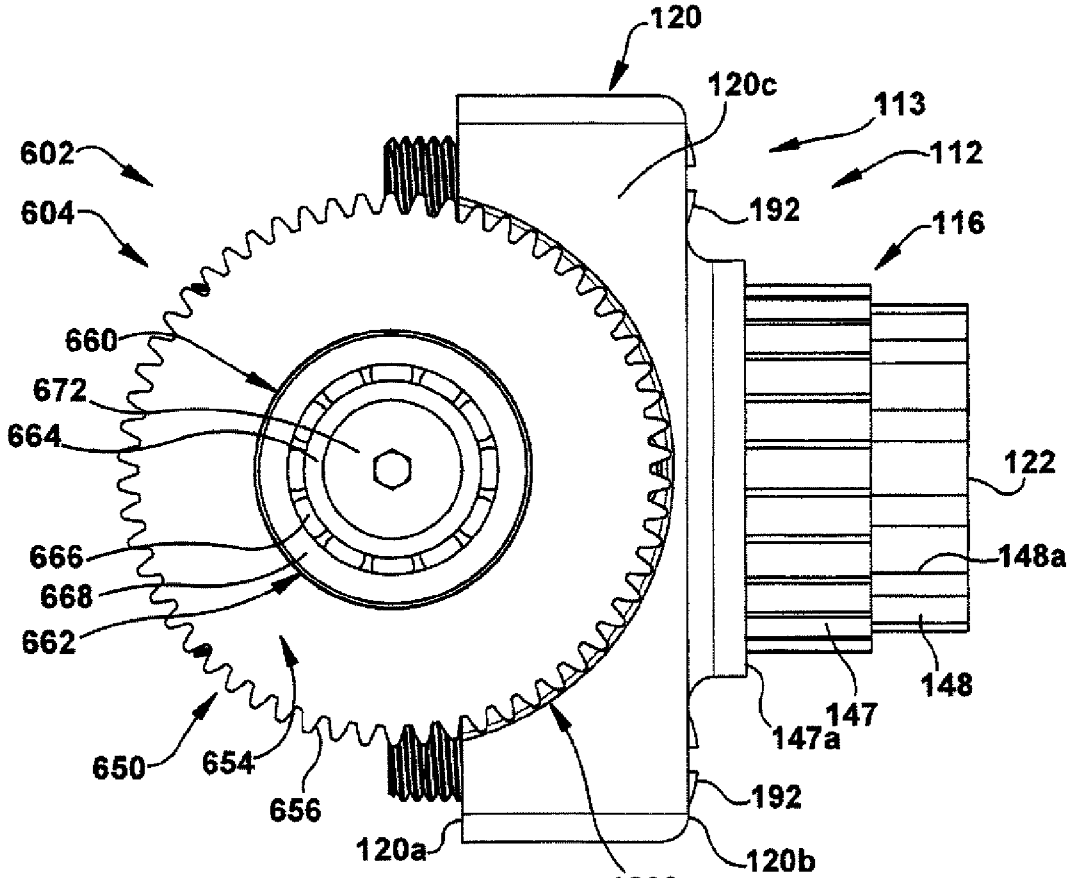

120
120c
113
602
112
604
192
116
660
672
664
122
666
148a
668
662
148
147
147a
650
654
656
192
120a
120b
120f

Fig. 35

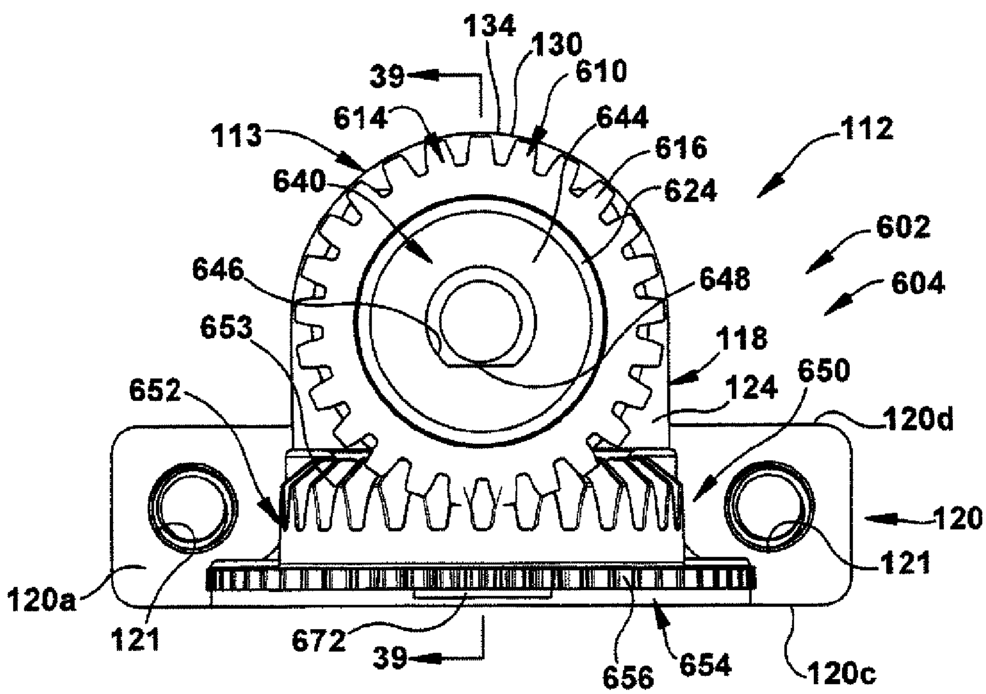

134
130
39
610
614
644
113
616
112
640
624
602
646
648
604
653
118
650
124
652
120d
120
121
120a
121
672
39
656
654
120c

Fig. 36

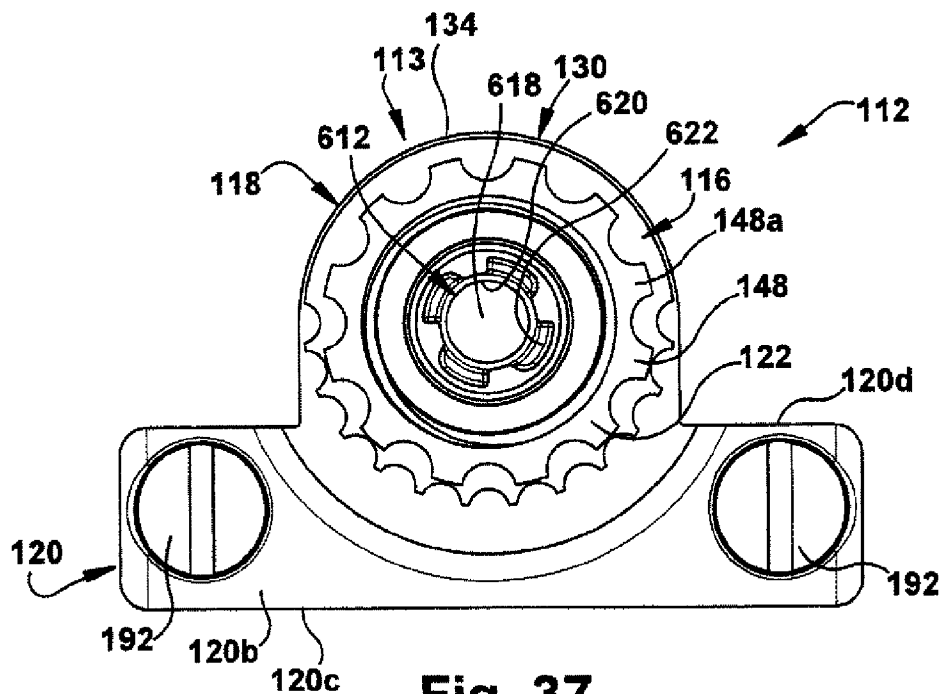

134
113
618
130
620
612
622
112
118
116
148a
148
122
120d
120
192
192
120b
120c

Fig. 37

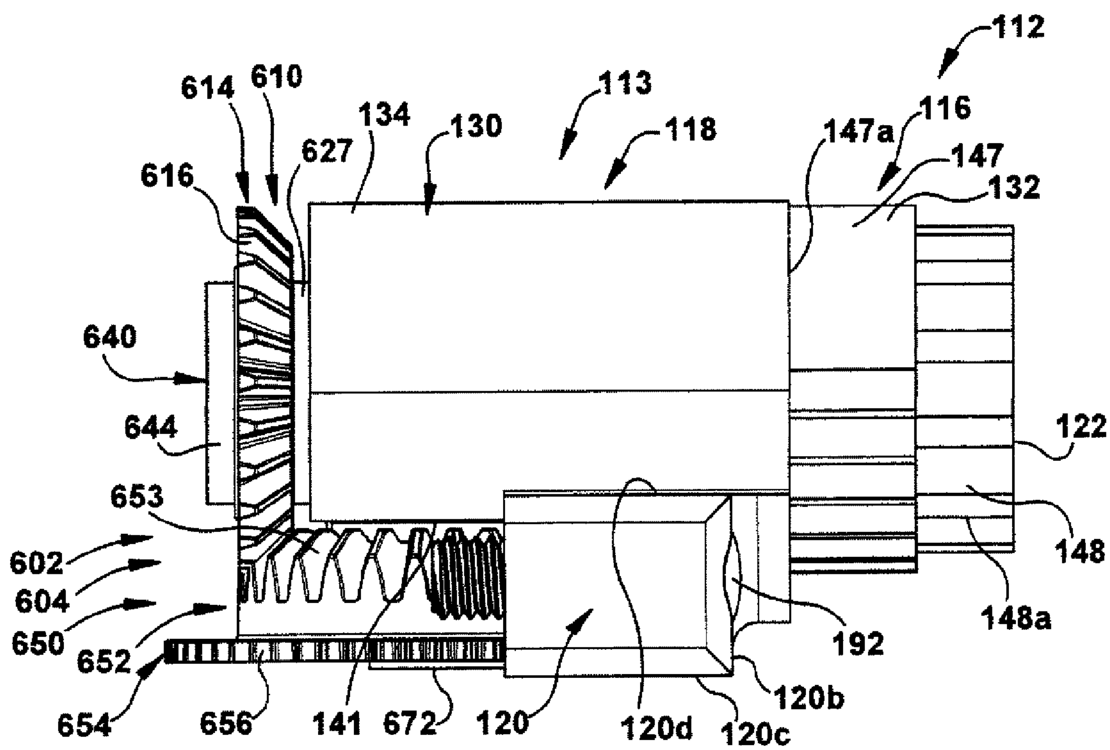
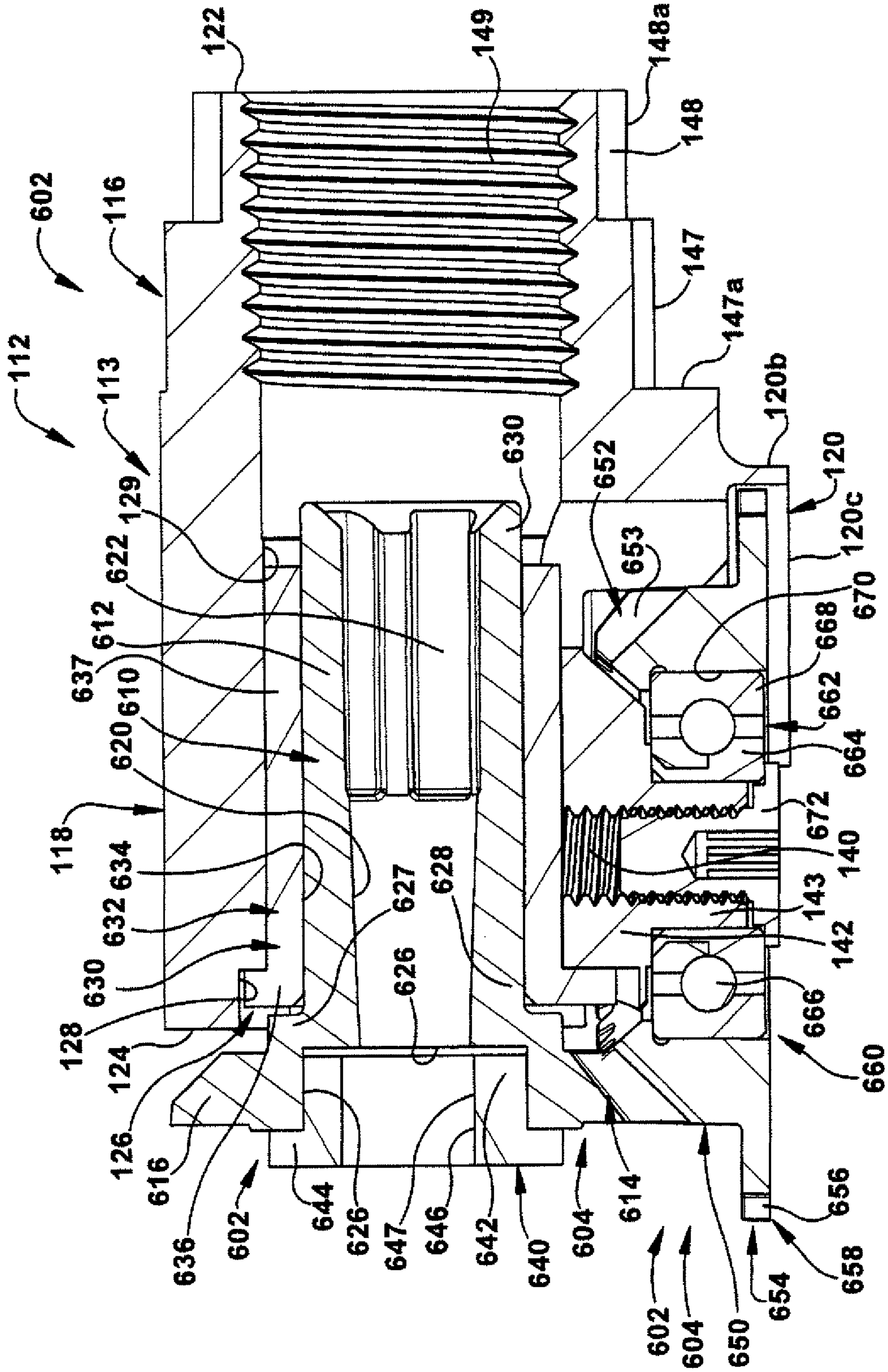

112
614
610
113
134
130
118
116
616
627
147a
147
132
640
644
122
653
602
604
650
652
148
148a
192
120b
654
656
141
672
120
120d
120c

Fig. 38



122
149
148a
148
602
116
147
147a
112
113
120b
120
120c
630
652
653
129
622
612
637
610
670
668
662
664
620
118
634
632
630
128
124
126
616
636
602
644
626
647
646
642
640
604
614
602
604
650
654
658
656
660
666
142
143
140
672
627
628
626

Fig. 39

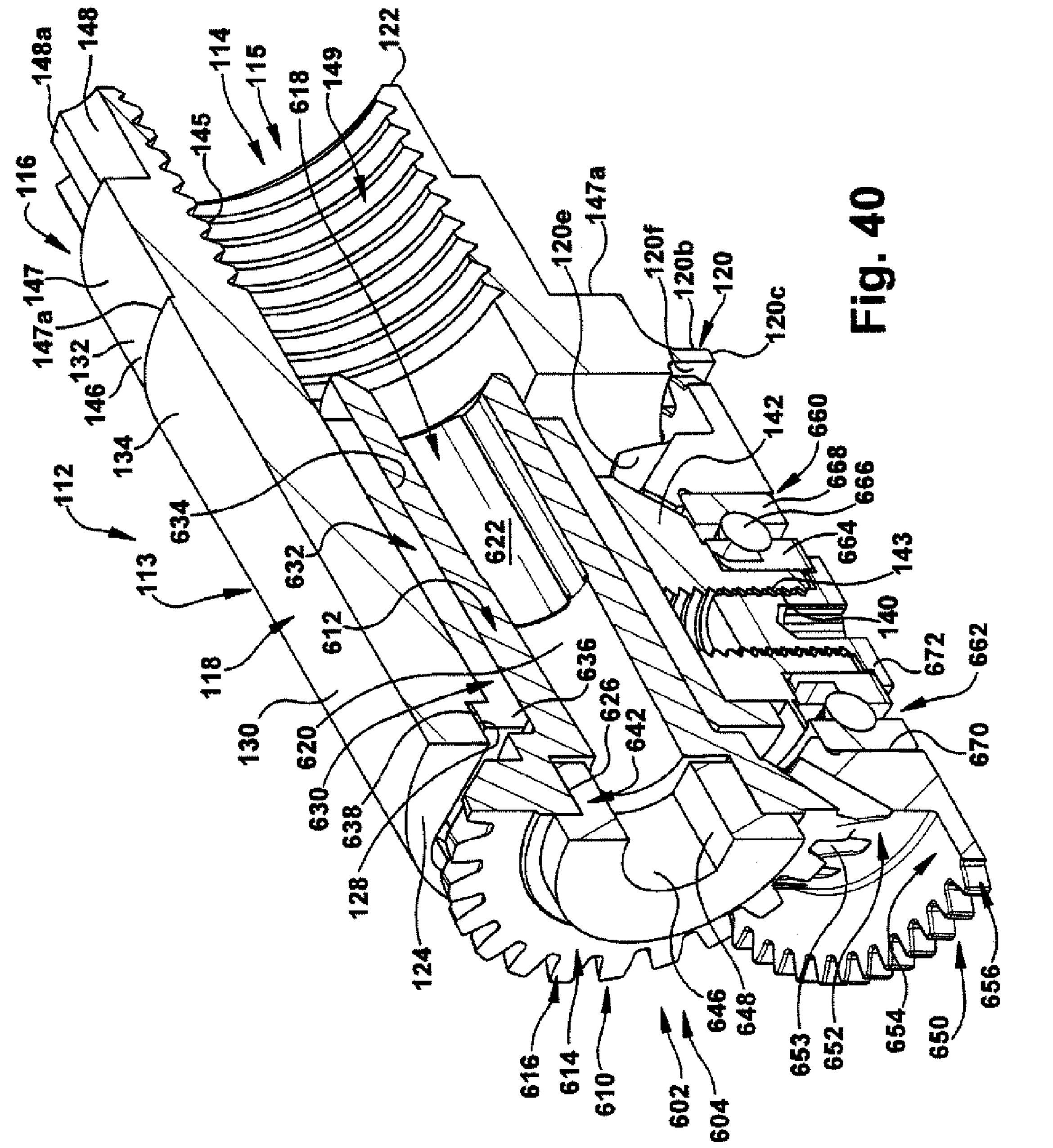

148a
148
116
114
115
145
618
149
122
147
147a
132
146
134
112
634
113
118
632
612
622
130
620
636
626
630
638
642
128
124
120e
147a
120f
120b
120
120c
142
660
668
666
664
143
140
672
662
670
646
648
616
614
610
602
604
653
652
654
650
656

Fig. 40

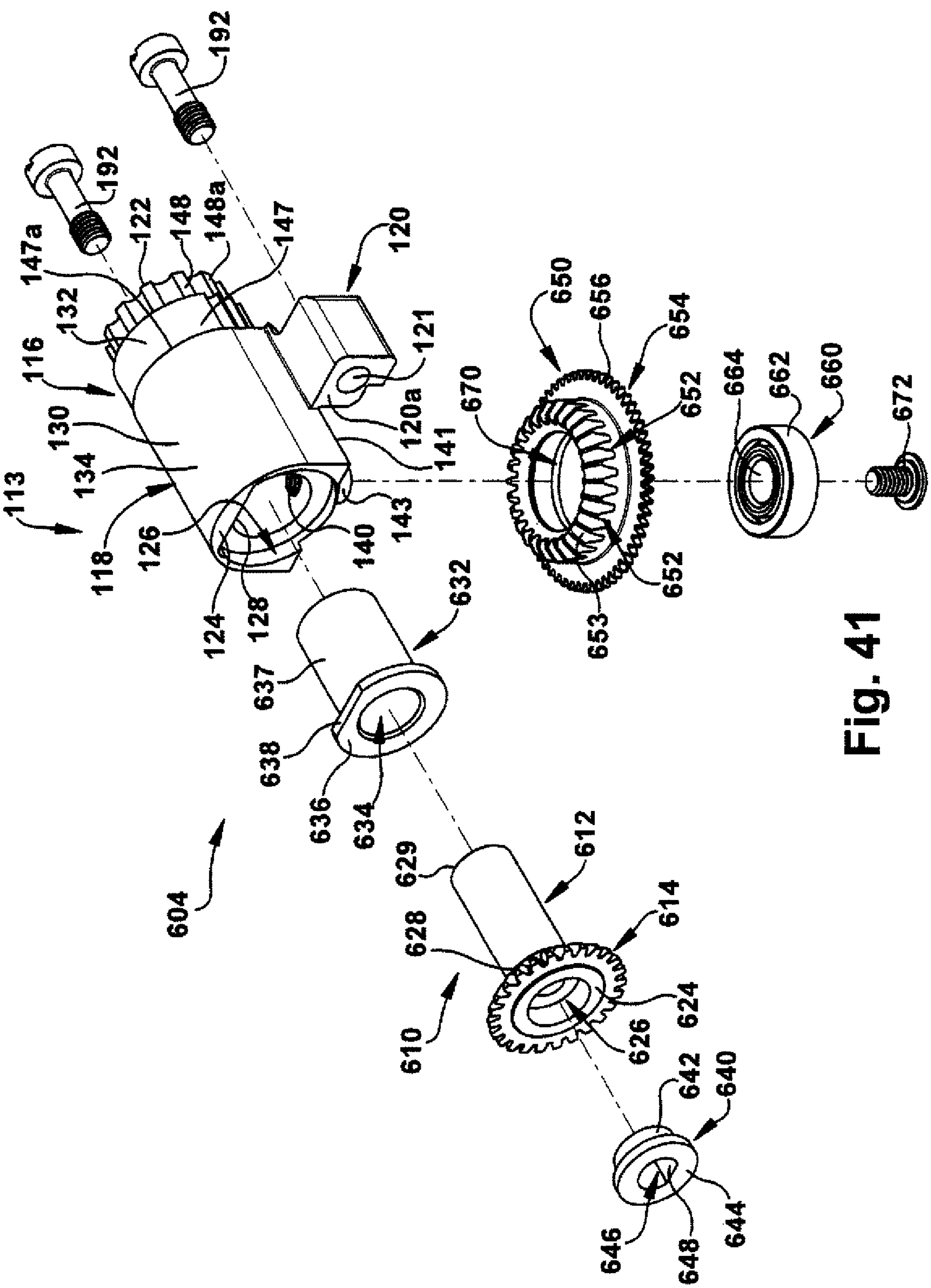

192
192
147a
122
148
148a
147
120
132
116
121
130
120a
134
141
113
143
126
140
118
124
128
650
656
654
670
652
664
662
660
672
652
653
632
637
638
636
634
604
629
612
628
614
624
626
610
642
640
644
646
648

Fig. 41

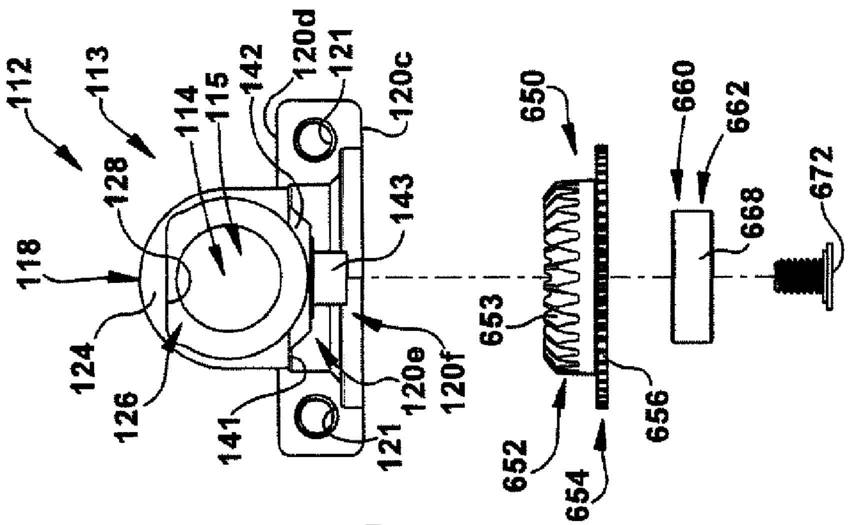

112
113
118
124
126
128
114
115
142
120d
121
120c
143
120e
120f
141
121
650
652
653
654
656
660
662
668
672

Fig. 43

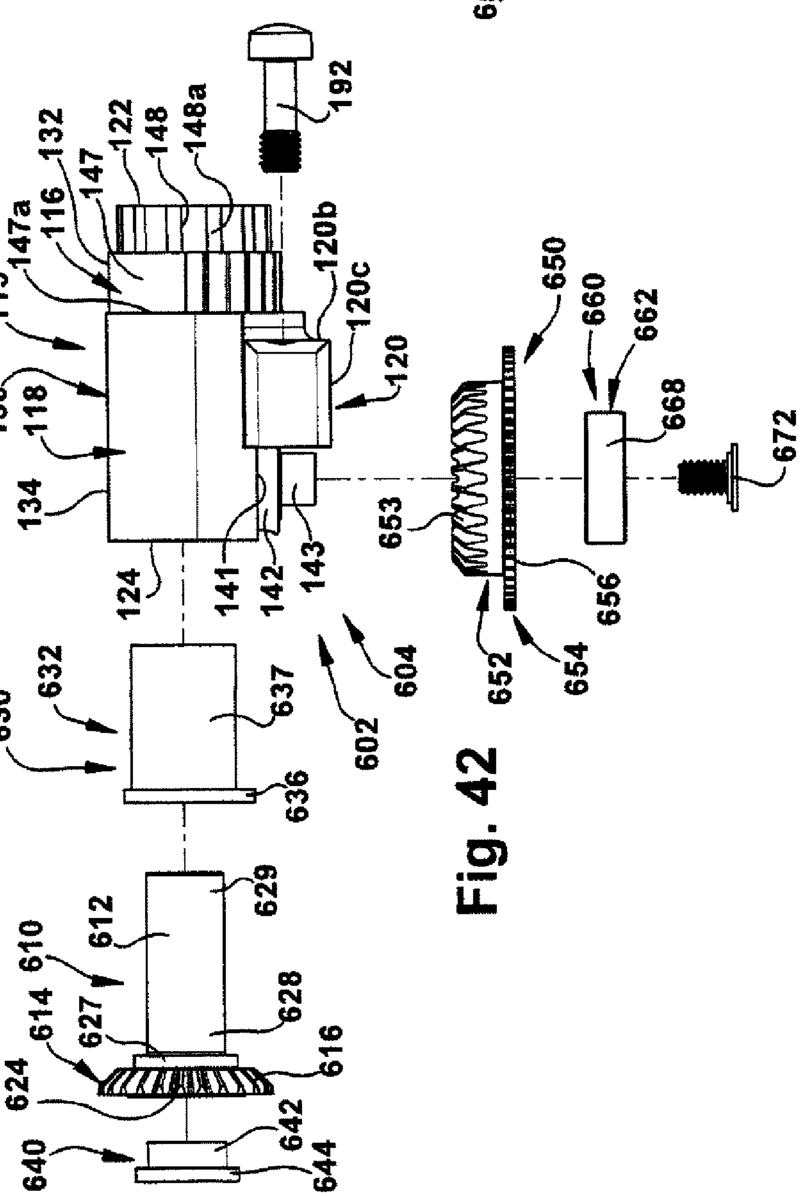

112
113
130
118
134
124
147a
116
147
132
122
148
148a
192
120b
120c
120
141
142
143
604
602
650
652
653
654
656
660
662
668
672
630
632
637
636
610
612
614
627
628
629
616
624
640
642
644

Fig. 42

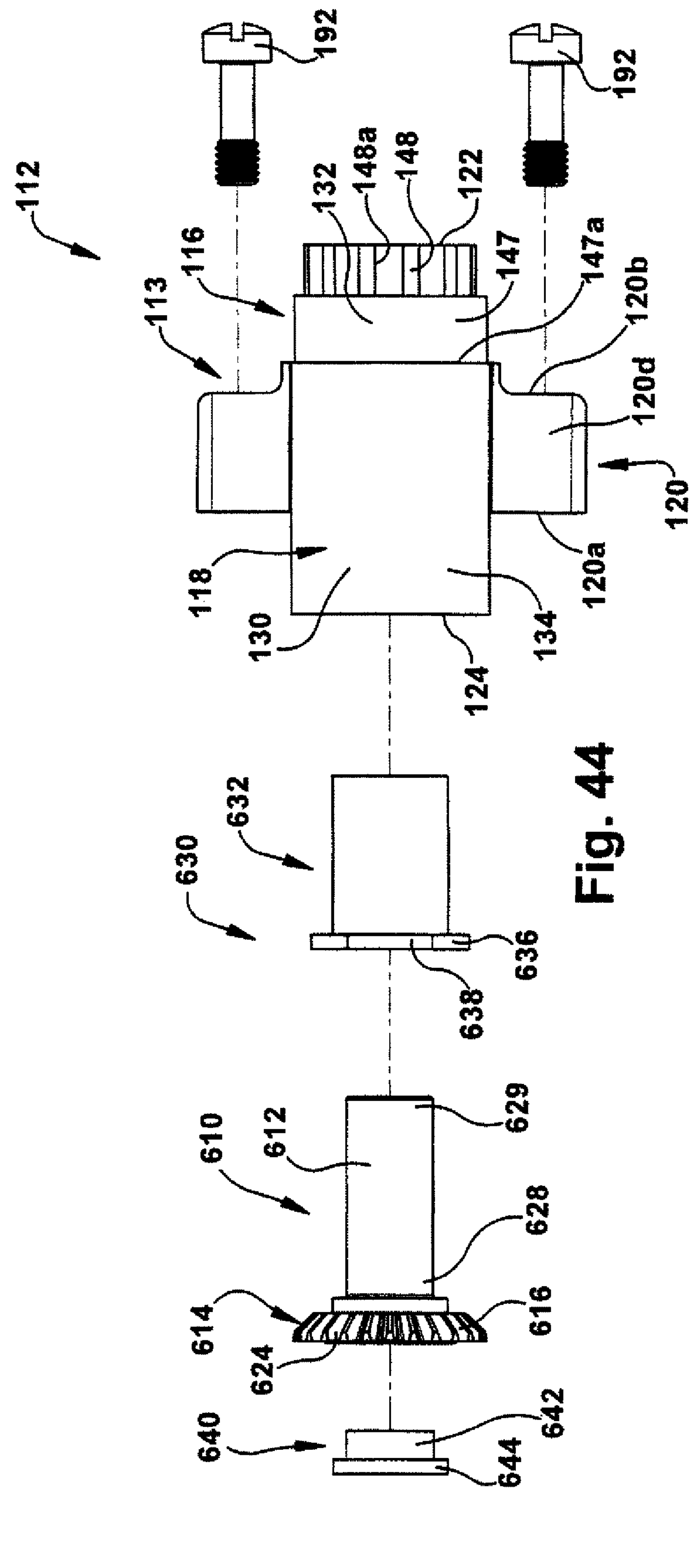

192
192
112
113
116
132
148a
148
122
147
147a
120b
120d
120
120a
118
130
124
134
630
632
636
638
610
612
629
628
614
616
624
640
642
644

Fig. 44

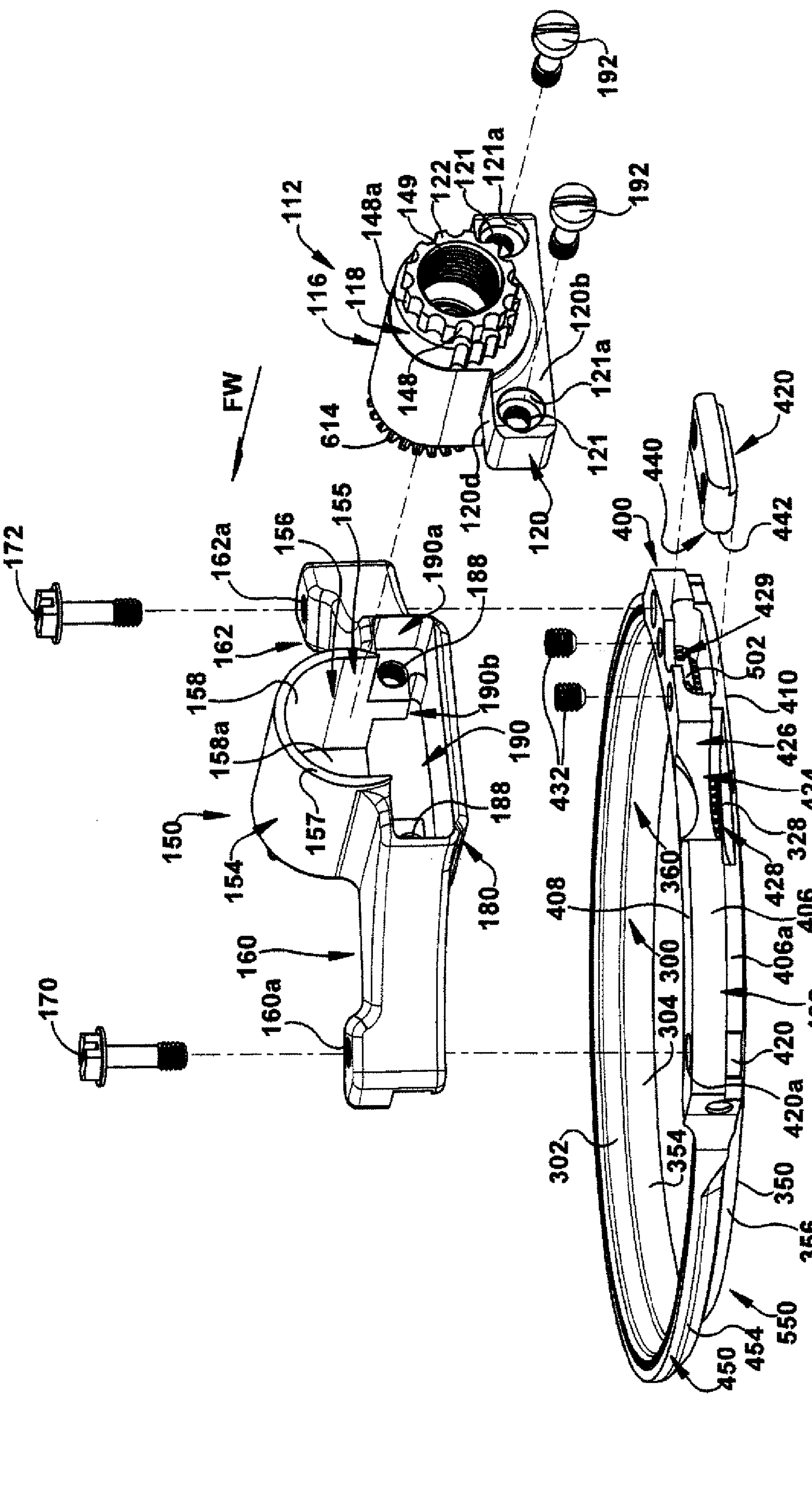

192
192
112
116
118
148a
149
122
121
121a
120b
121a
121
148
614
FW
120d
120
420
440
442
400
429
502
410
426
424
328
428
406
406a
402
420
420a
350
356
550
454
450
302
354
304
300
408
360
432
172
162a
156
155
190a
188
162
158
190b
158a
190
157
154
150
188
180
160
160a
170

Fig. 45

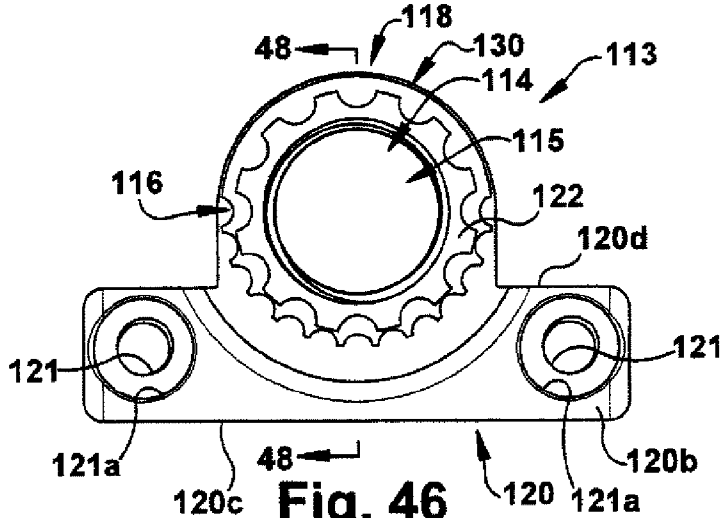


Fig. 46

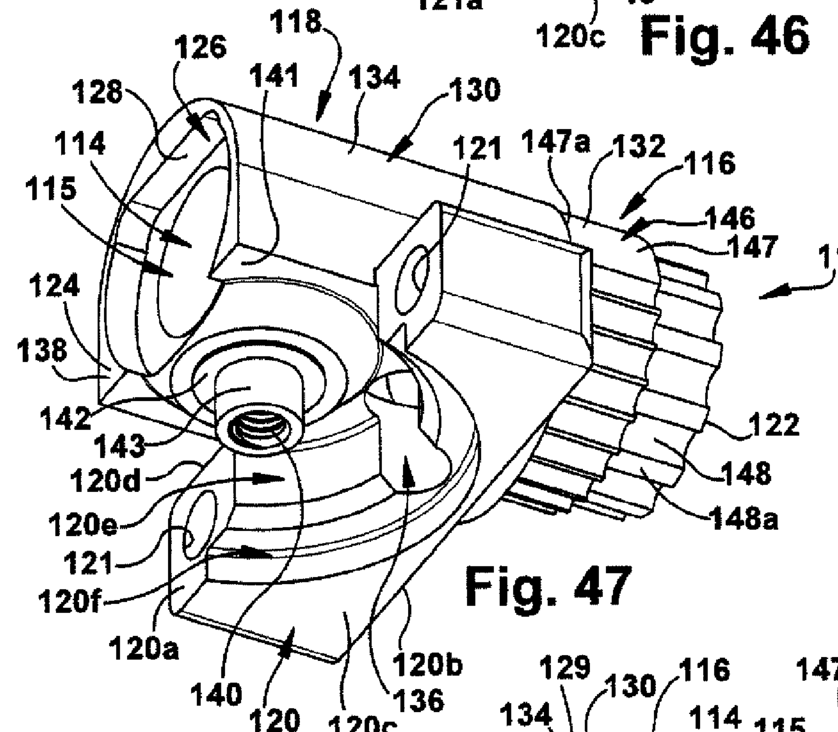


Fig. 47

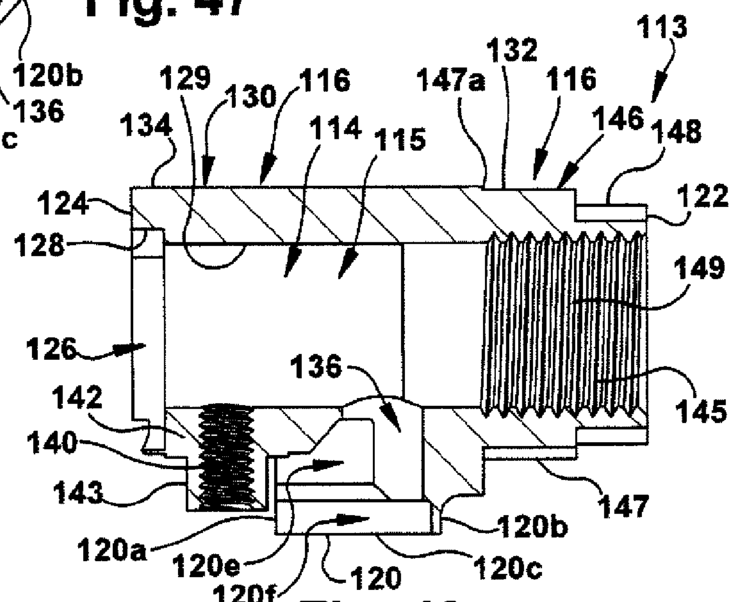


Fig. 48

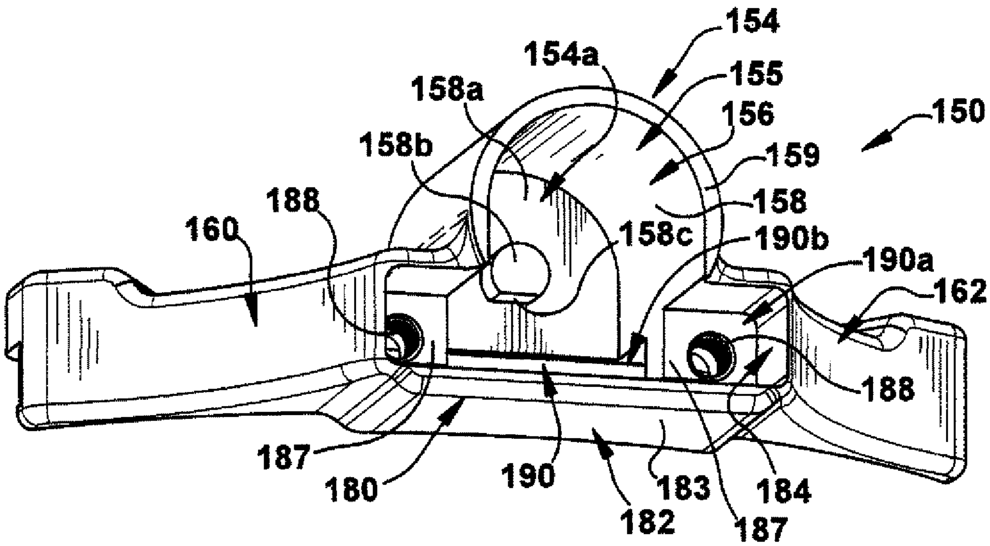

154
154a
155
158a
156
150
158b
159
158
188
160
158c
190b
190a
162
188
187
180
190
183
184
182
187

Fig. 49

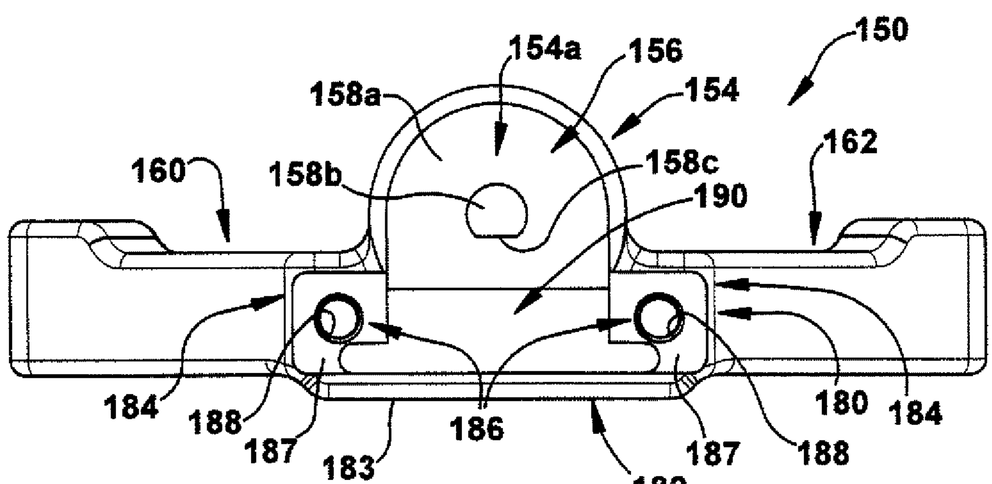

150
154a
156
154
158a
158c
160
162
158b
190
184
188
187
183
186
180
184
187
188
182

Fig. 50

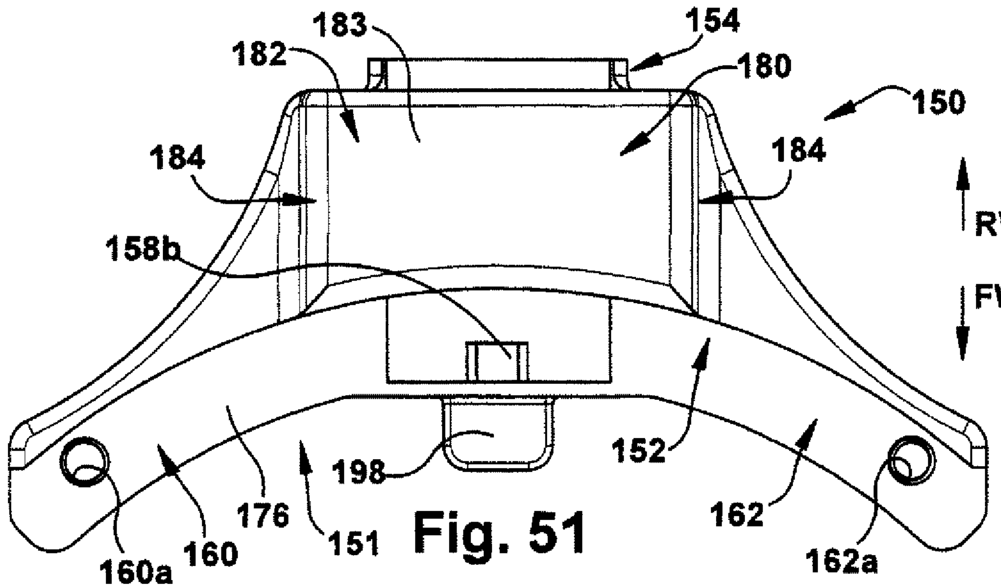

183
154
182
180
150
184
184
RW
158b
FW
152
198
176
162
160a
160
151
162a

Fig. 51

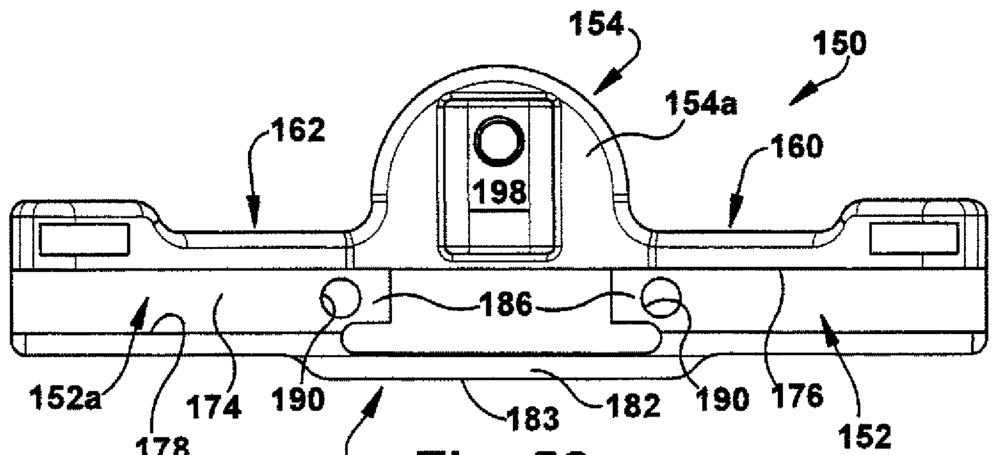
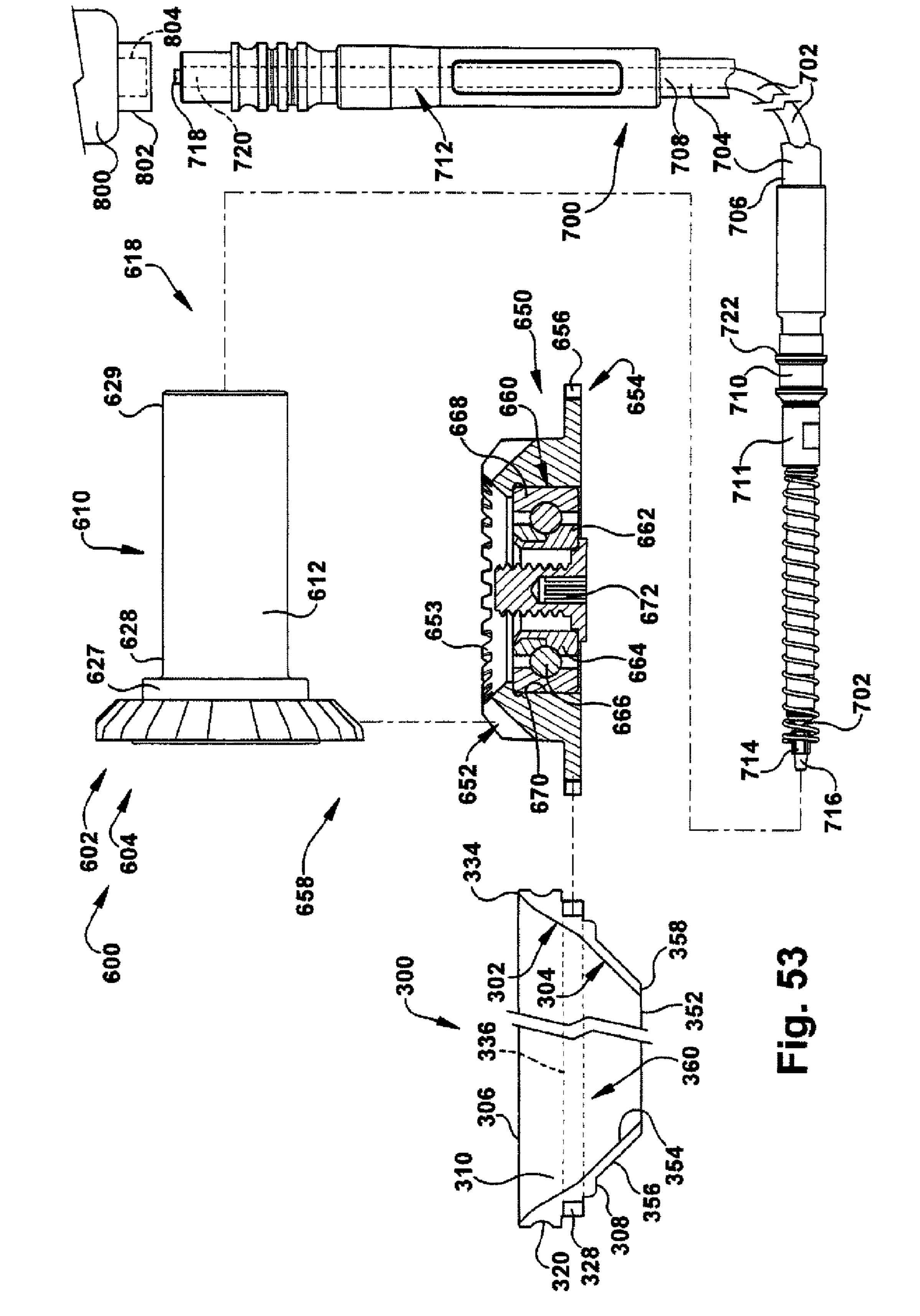

154
150
154a
162
160
198
186
152a
174
190
182
190
176
178
183
152
180

Fig. 52



800
802
804
718
720
712
700
708
704
702
706
722
710
711
714
716
618
629
610
612
628
627
602
604
600
658
650
656
654
660
668
662
672
653
664
666
670
652
334
302
304
358
352
300
336
360
306
310
354
356
308
320
328

Fig. 53

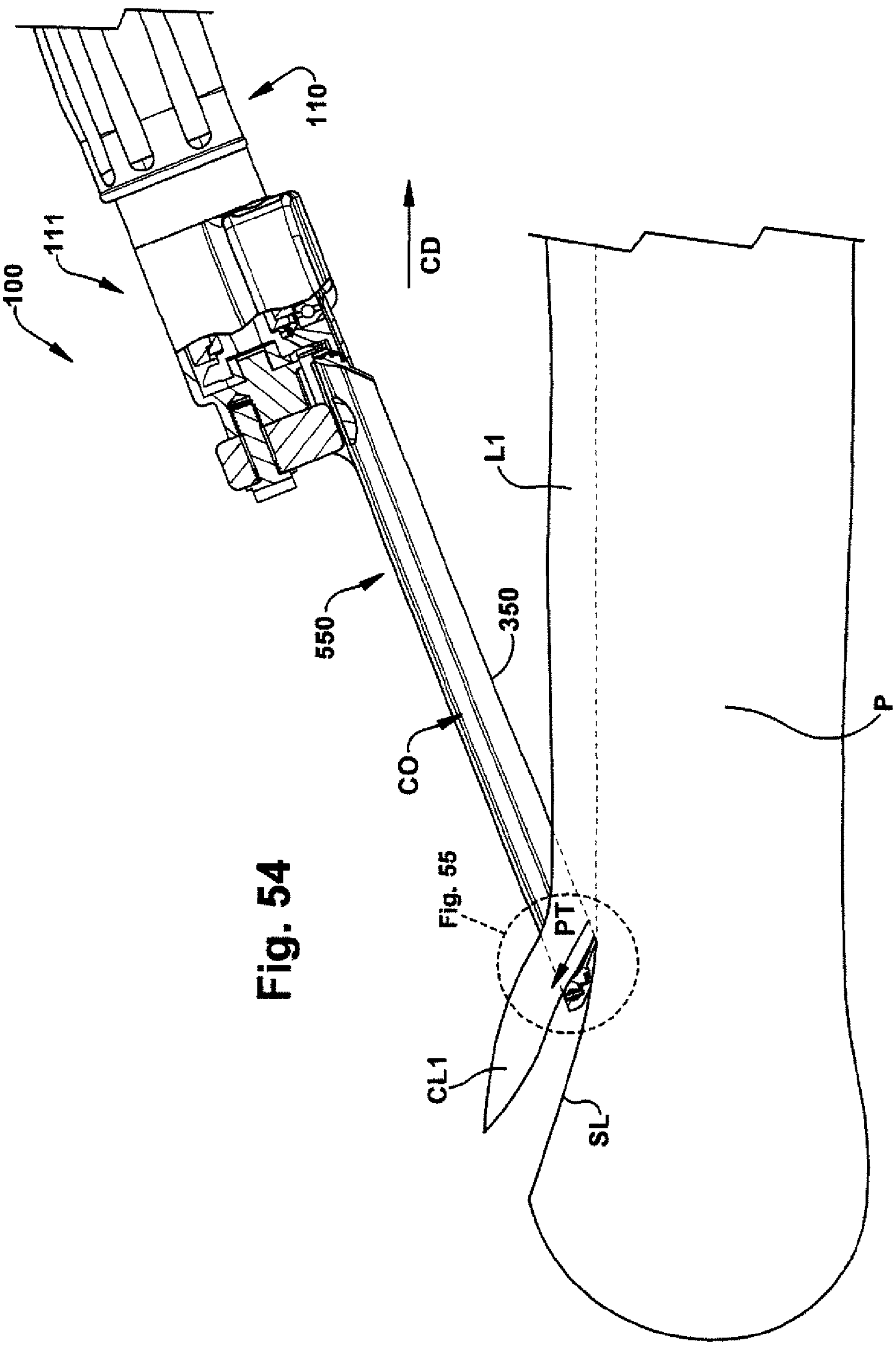


Fig. 54

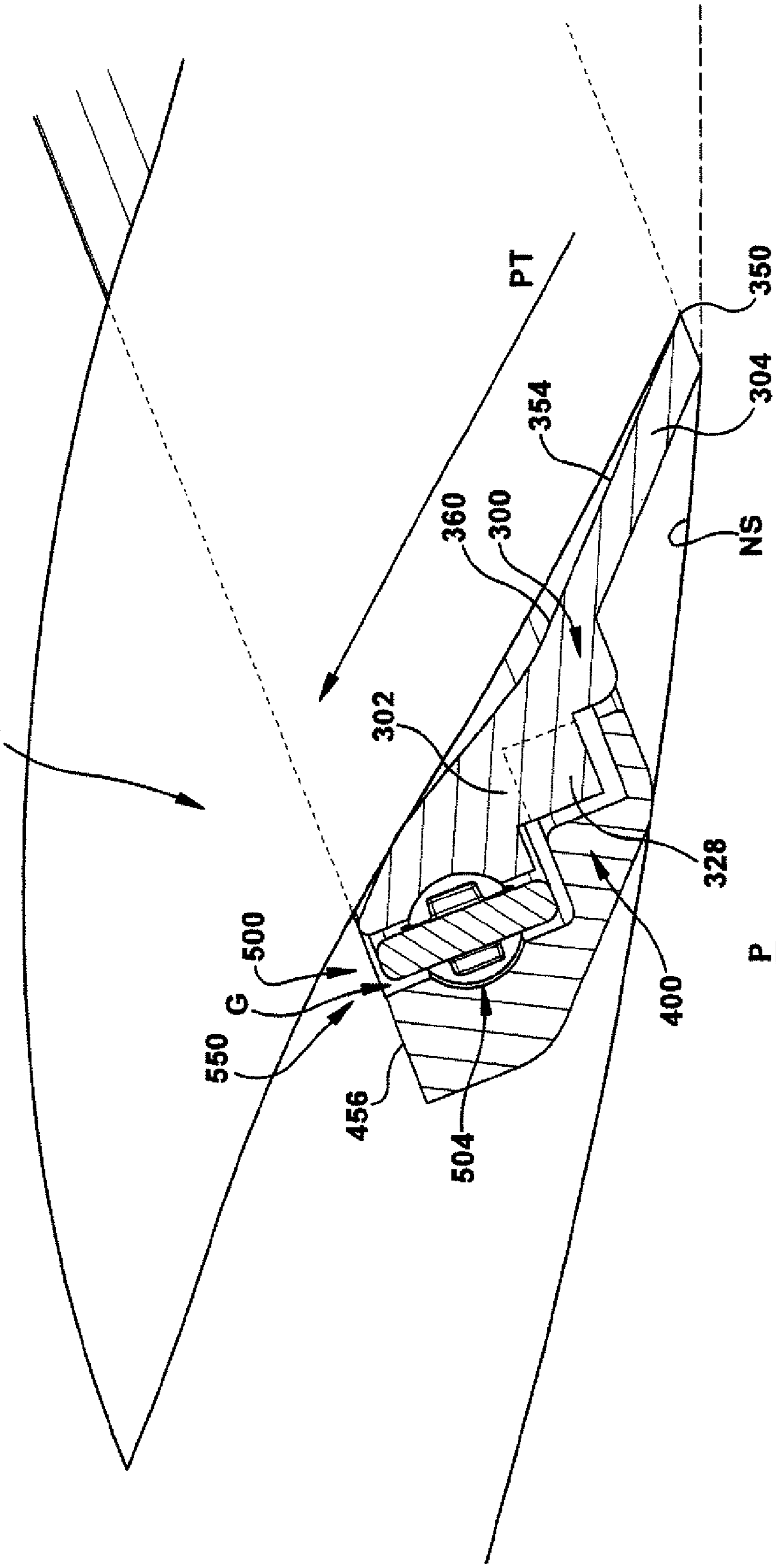


Fig. 55

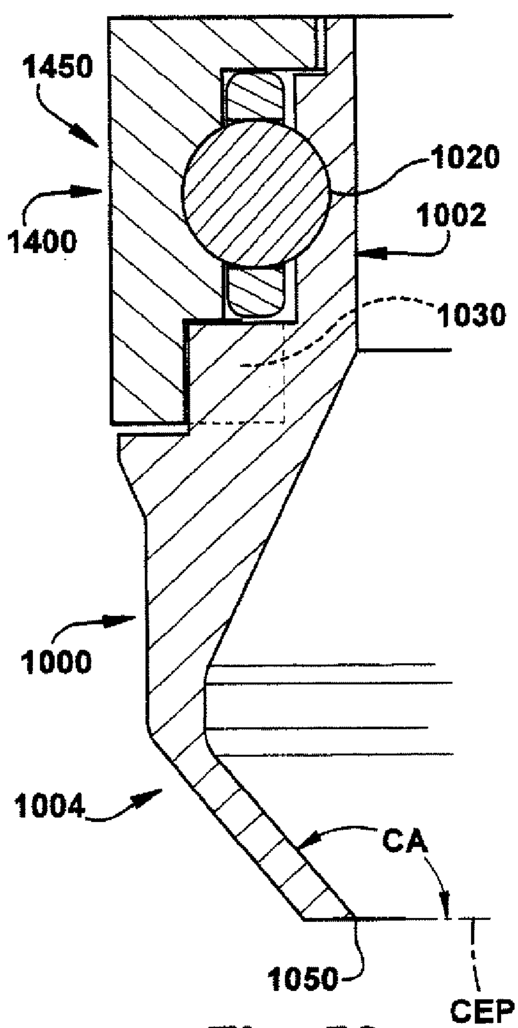

1450
1400
1020
1002
1030
1000
1004
CA
1050
CEP

Fig. 56

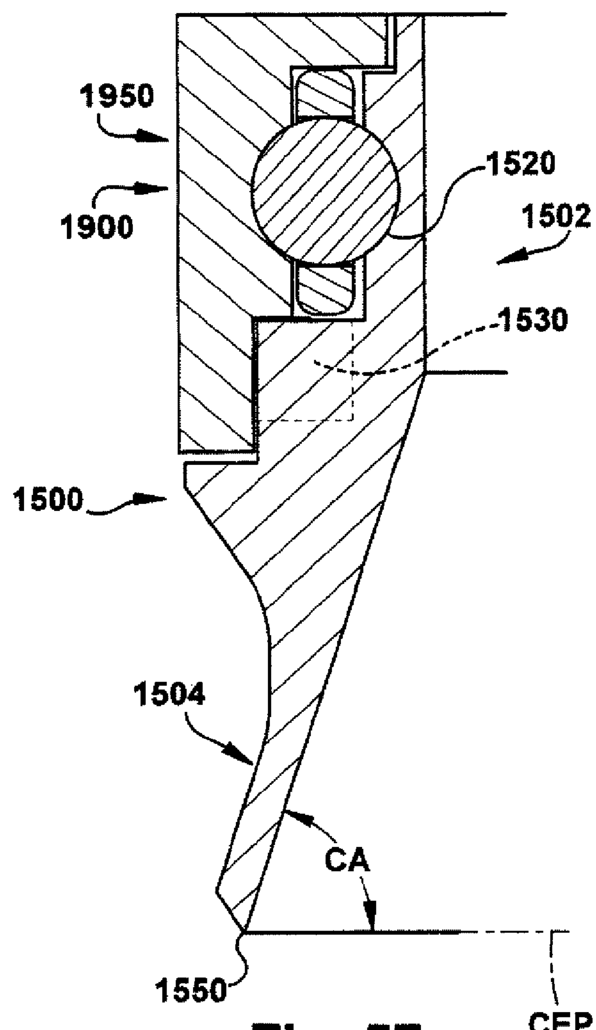

1950
1900
1520
1502
1530
1500
1504
CA
1550
CEP

Fig. 57

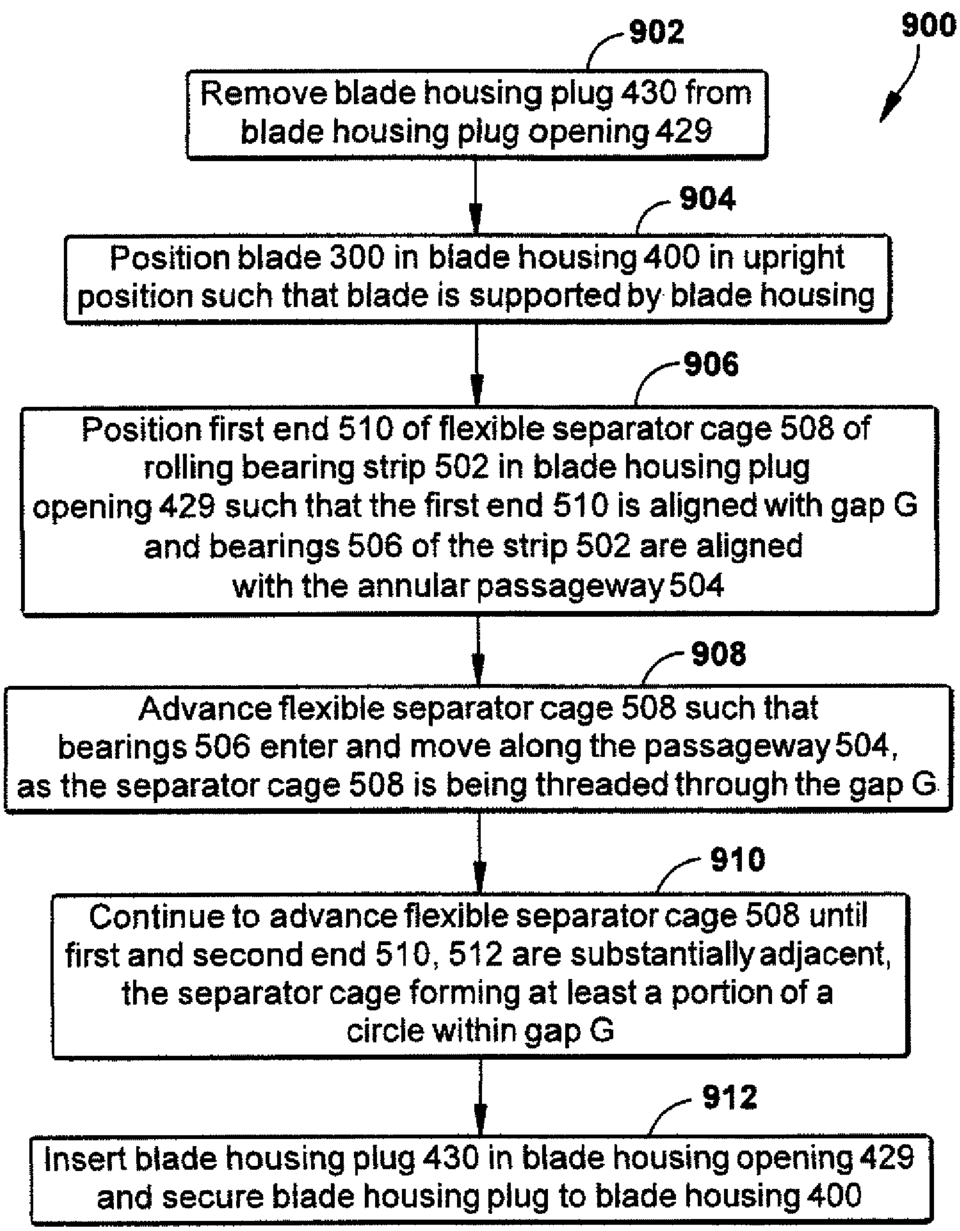

900
902
Remove blade housing plug 430 from blade housing plug opening 429
904
Position blade 300 in blade housing 400 in upright position such that blade is supported by blade housing
906
Position first end 510 of flexible separator cage 508 of rolling bearing strip 502 in blade housing plug opening 429 such that the first end 510 is aligned with gap G and bearings 506 of the strip 502 are aligned with the annular passageway 504
908
Advance flexible separator cage 508 such that bearings 506 enter and move along the passageway 504, as the separator cage 508 is being threaded through the gap G
910
Continue to advance flexible separator cage 508 until first and second end 510, 512 are substantially adjacent, the separator cage forming at least a portion of a circle within gap G
912
Insert blade housing plug 430 in blade housing opening 429 and secure blade housing plug to blade housing 400

Fig. 58

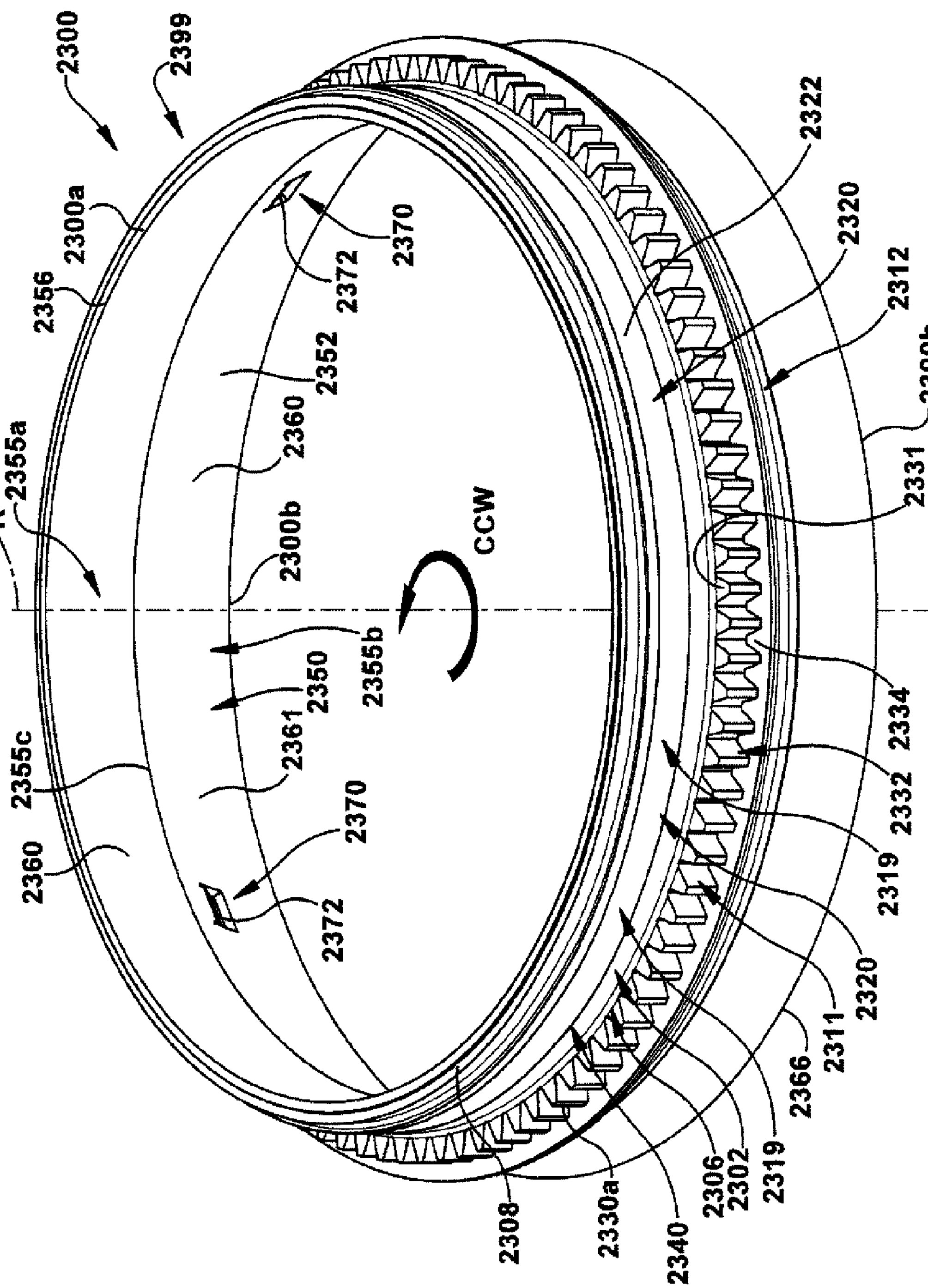

2300
2399
2300a
2356
2355a
R'
2300b
2352
2360
2370
2372
2322
2320
2312
2300b
2331
CCW
2355b
2350
2361
2355c
2360
2370
2372
2334
2332
2319
2320
2311
2366
2319
2302
2306
2340
2330a
2308

Fig. 59

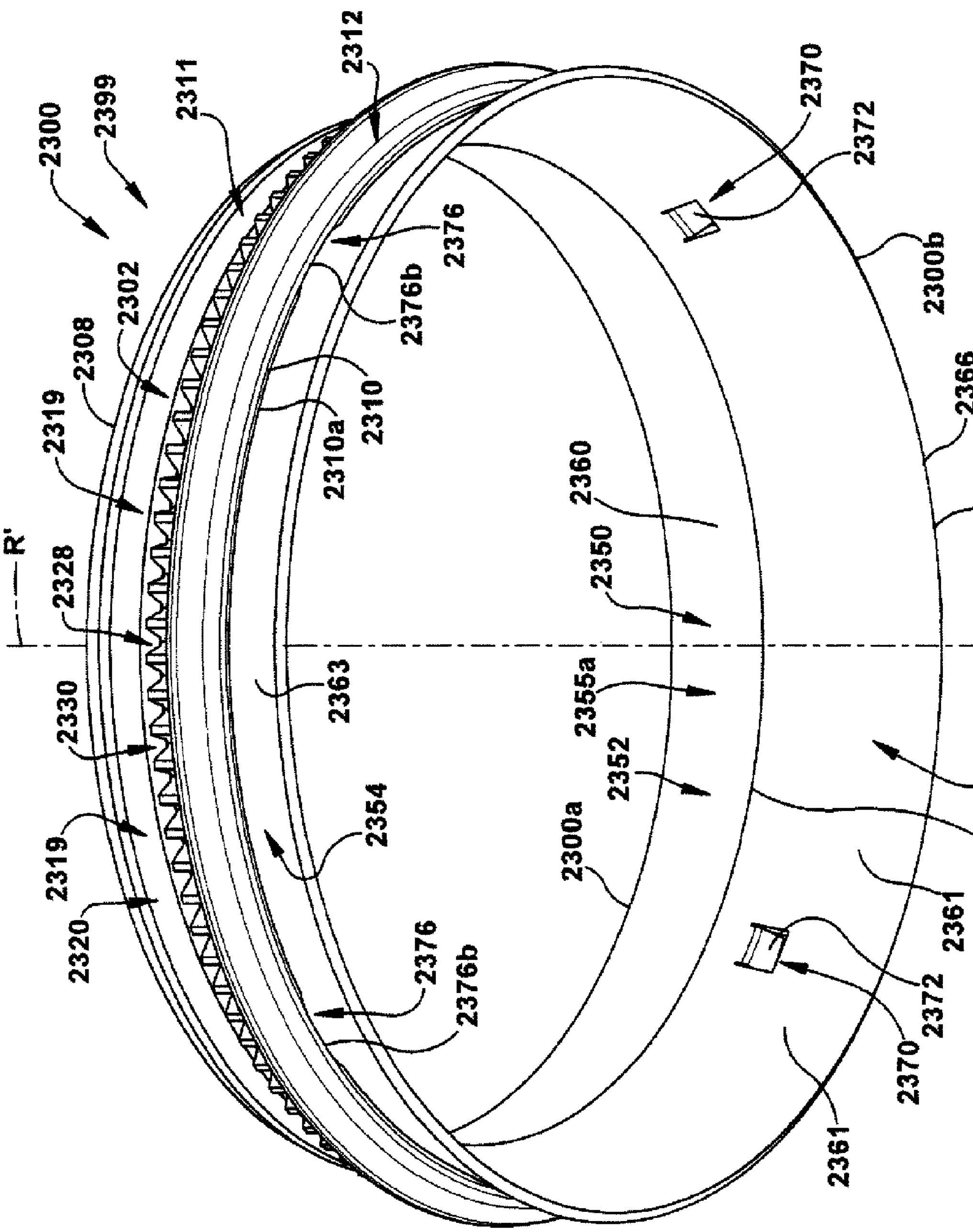

2300
2399
2311
2312
2370
2372
2376
2376b
2300b
2302
2308
2319
2310
2310a
2366
2368
2360
R'
2328
2350
2363
2355a
2330
2352
2355b
2354
2355c
2300a
2361
2319
2320
2376
2376b
2372
2370
2361

Fig. 60

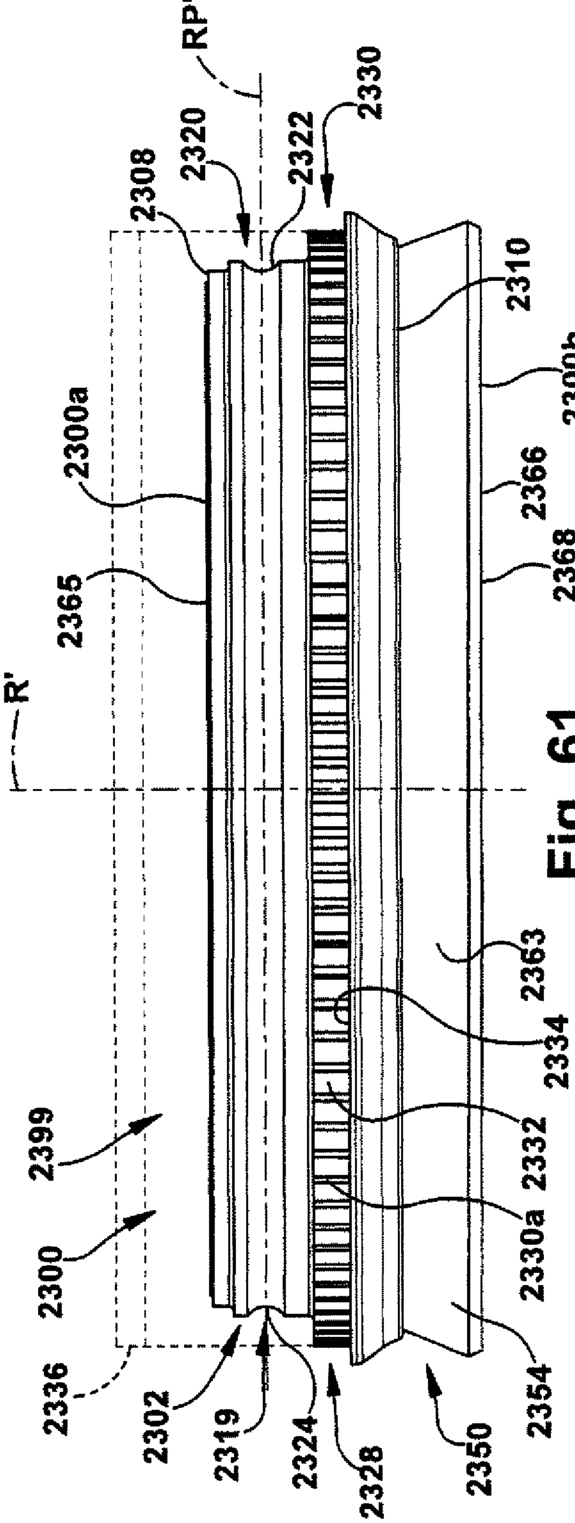

RP'
2330
2320
2322
2308
2310
2300b
2300a
2366
2368
2365
R'
2363
2334
2332
2399
2330a
2300
2354
2336
2302
2319
2324
2328
2350

Fig. 61

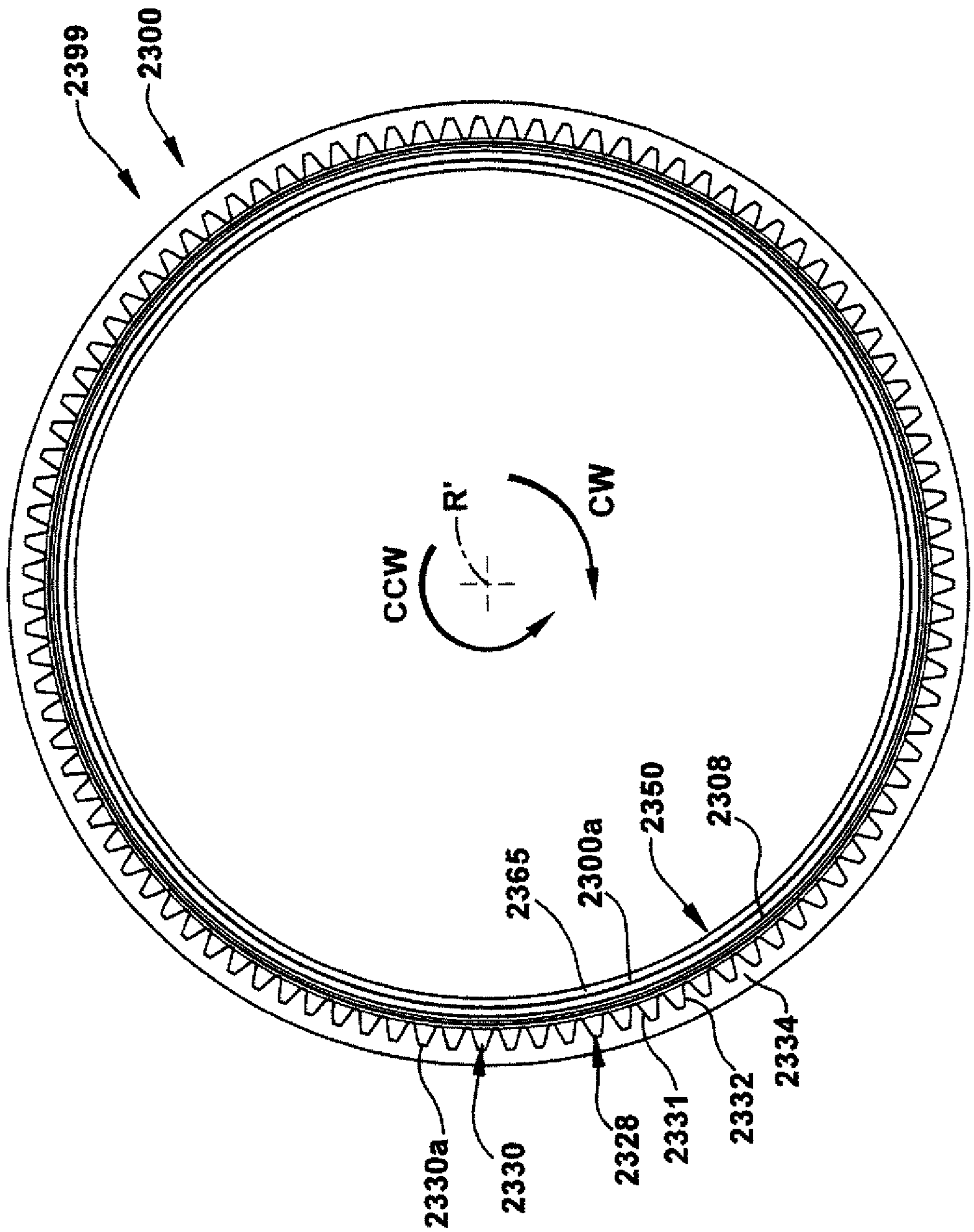

2399
2300
R'
CCW
CW
2365
2300a
2350
2308
2330a
2330
2328
2331
2332
2334

Fig. 62

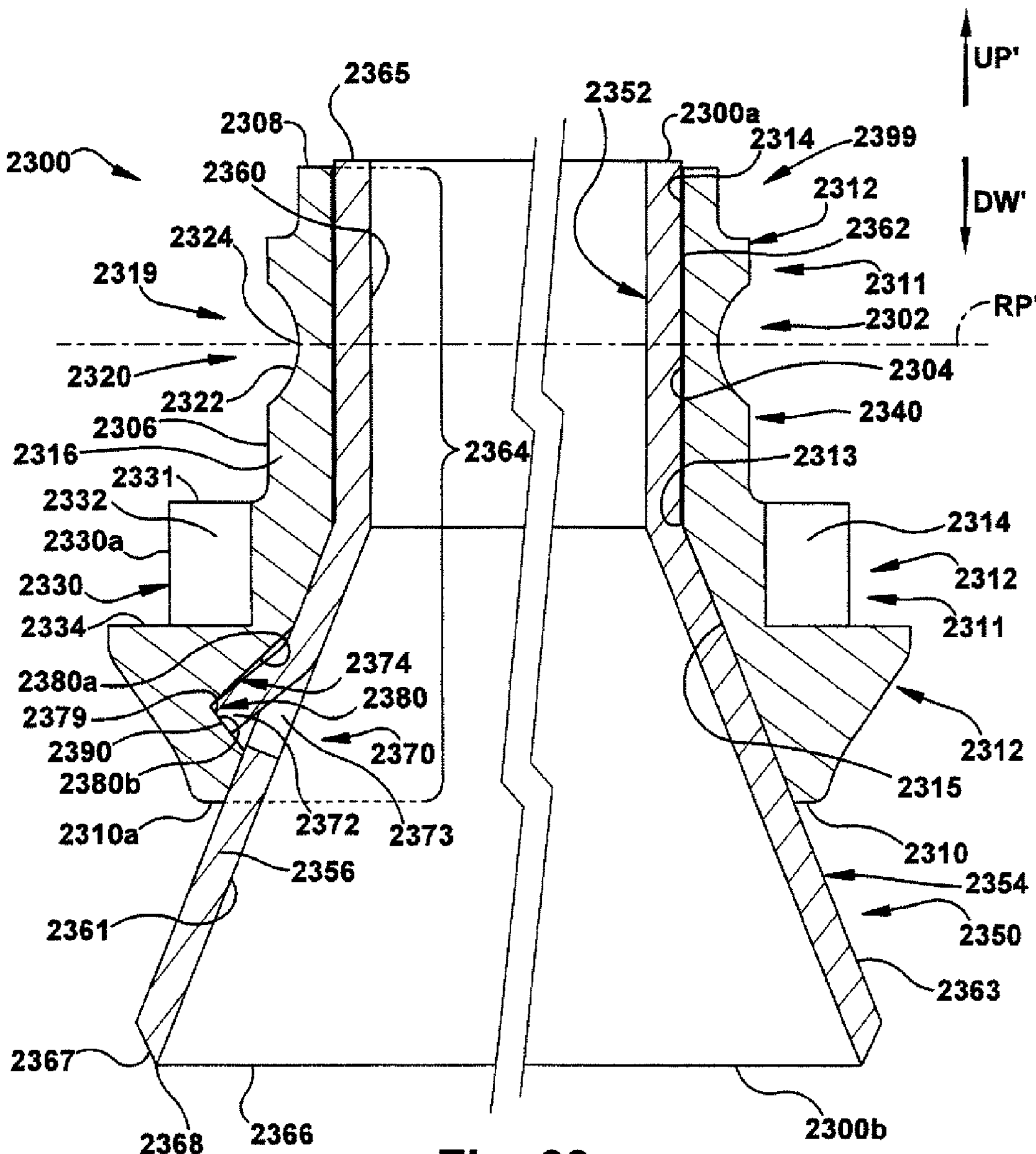

UP'
DW'
RP'
2300
2308
2365
2360
2324
2319
2320
2322
2306
2316
2331
2332
2330a
2330
2334
2380a
2379
2390
2380b
2310a
2374
2380
2370
2372
2373
2356
2361
2367
2368
2366
2364
2352
2300a
2314
2399
2312
2362
2311
2302
2304
2340
2313
2314
2312
2311
2312
2315
2310
2354
2350
2363
2300b

Fig. 63

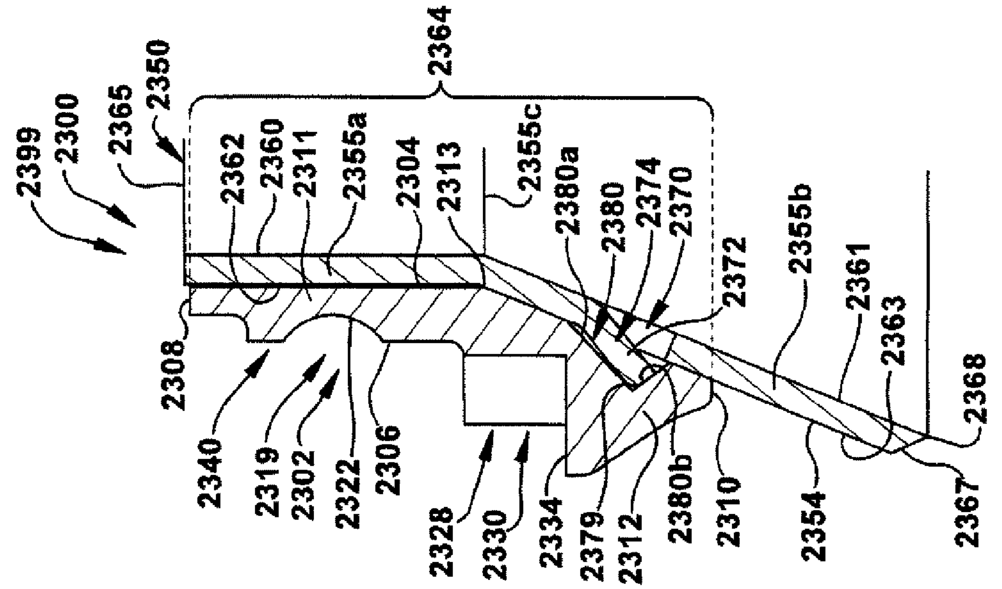


Fig. 66

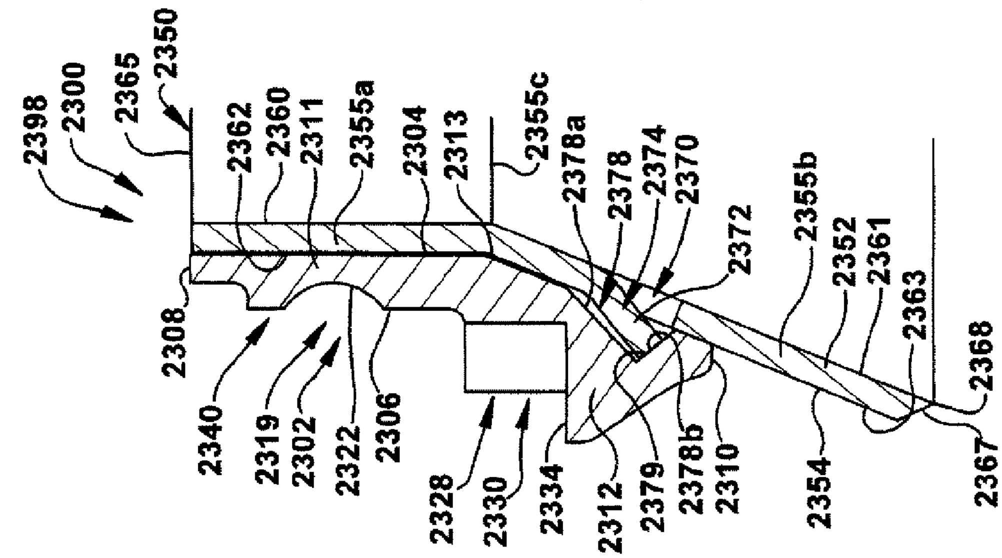


Fig. 65

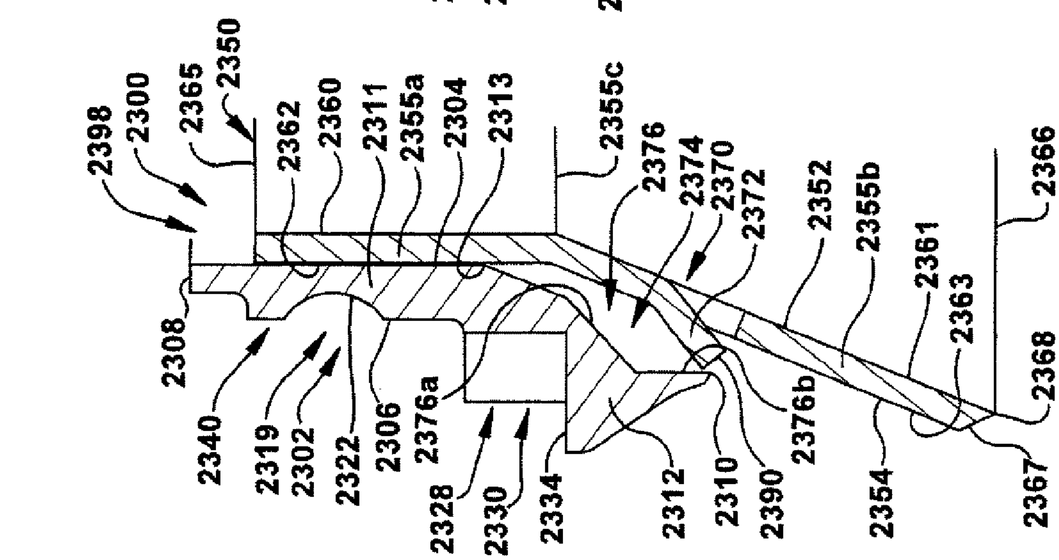
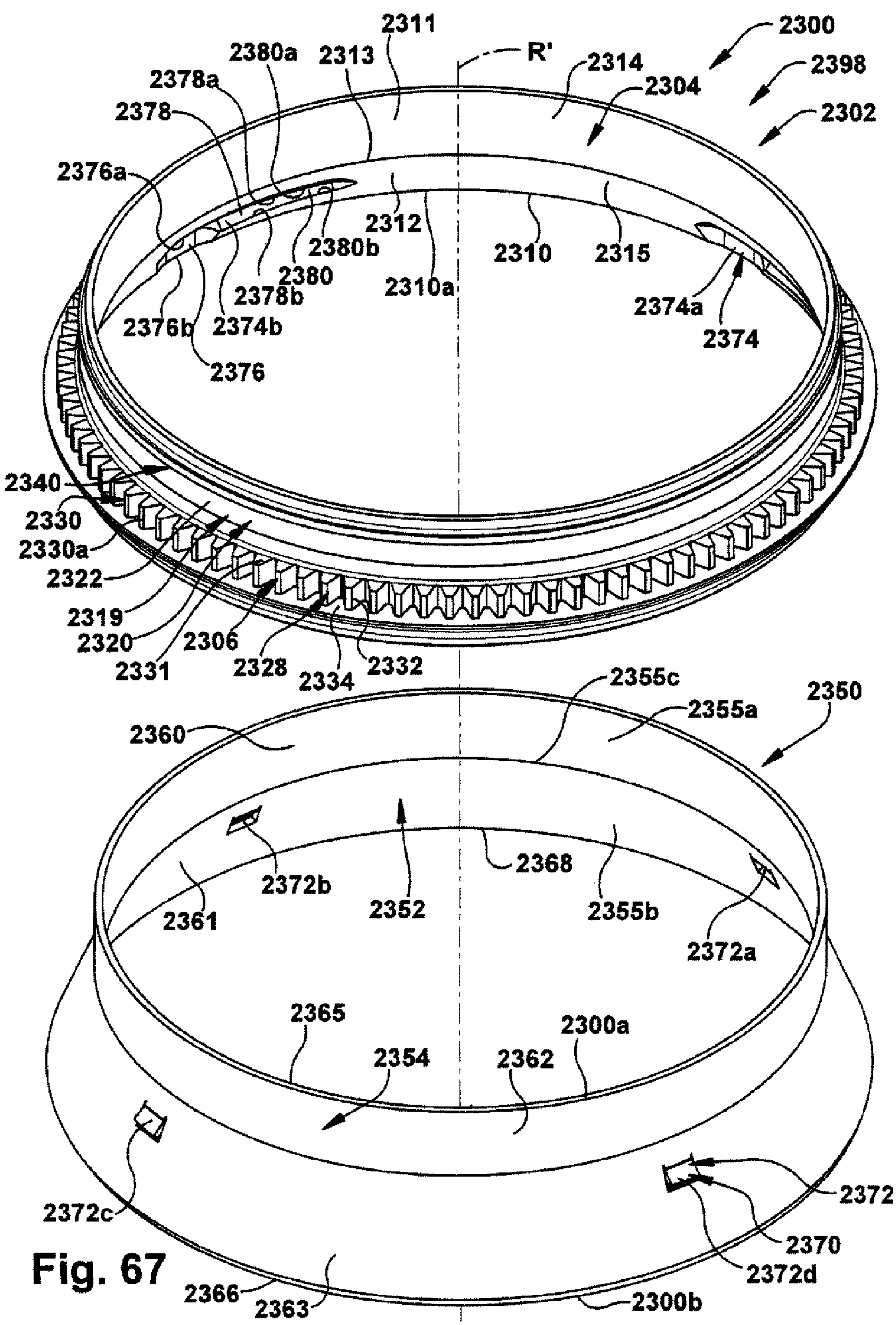


Fig. 64



2300
2398
2302
2304
2314
R'
2311
2313
2380a
2378a
2378
2376a
2312
2310
2315
2380b
2380
2378b
2310a
2374a
2374
2376b
2374b
2376
2340
2330
2330a
2322
2319
2320
2331
2306
2328
2334
2332
2355c
2350
2355a
2360
2368
2372b
2361
2352
2355b
2372a
2365
2300a
2354
2362
2372
2372c
2370
2372d
2366
2363
2300b

Fig. 67

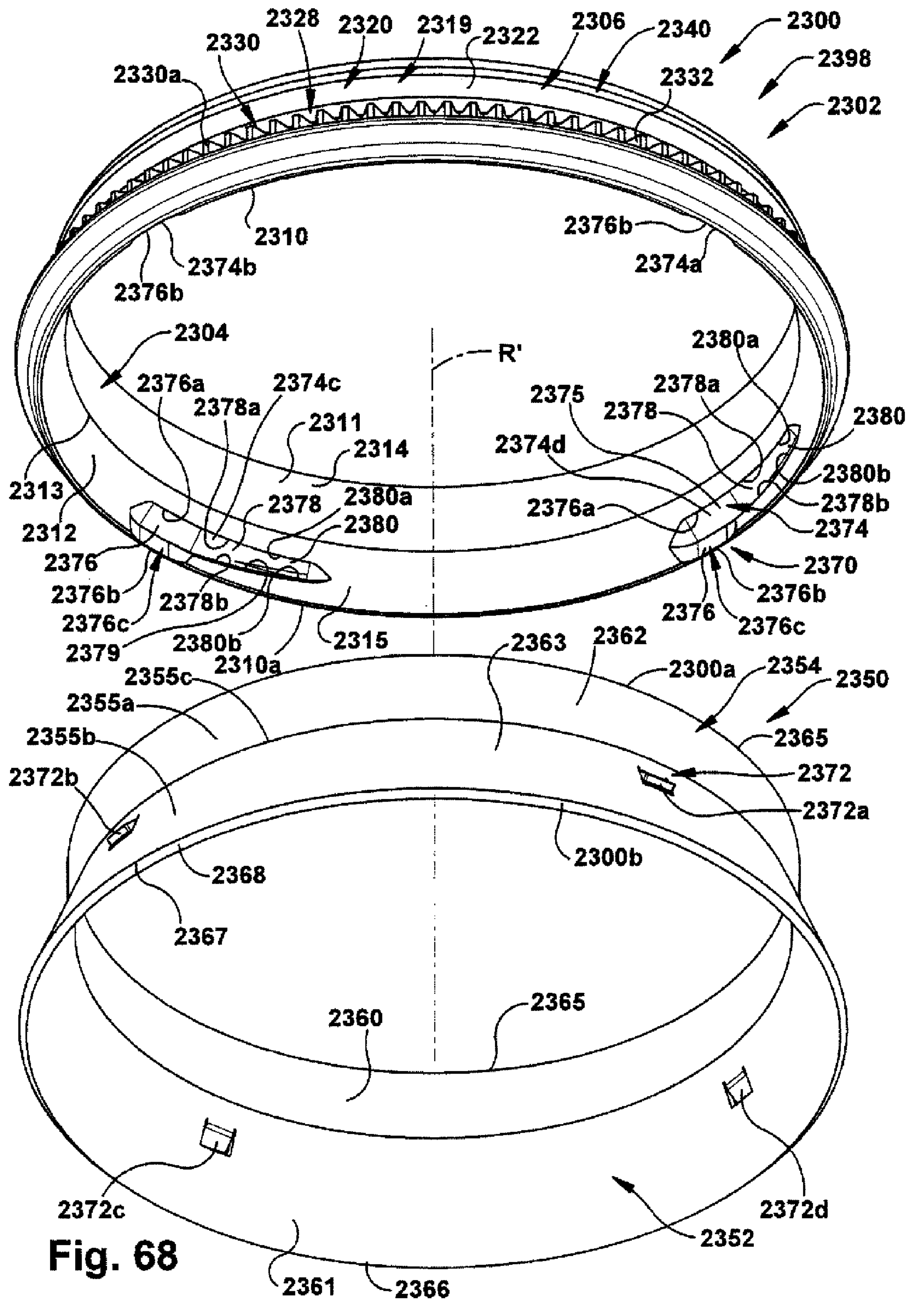

2300
2398
2302
2328
2320
2319
2322
2306
2340
2330
2330a
2332
2310
2376b
2374b
2376b
2374a
2304
R'
2380a
2376a
2374c
2378a
2375
2378a
2378
2380
2311
2314
2374d
2380b
2313
2378
2380a
2378b
2376a
2374
2312
2380
2370
2376
2376b
2376b
2378b
2376
2376c
2376c
2379
2380b
2315
2310a
2363
2362
2300a
2354
2350
2355c
2355a
2365
2355b
2372
2372b
2372a
2300b
2368
2367
2360
2365
2372c
2372d
2352
2361
2366

Fig. 68

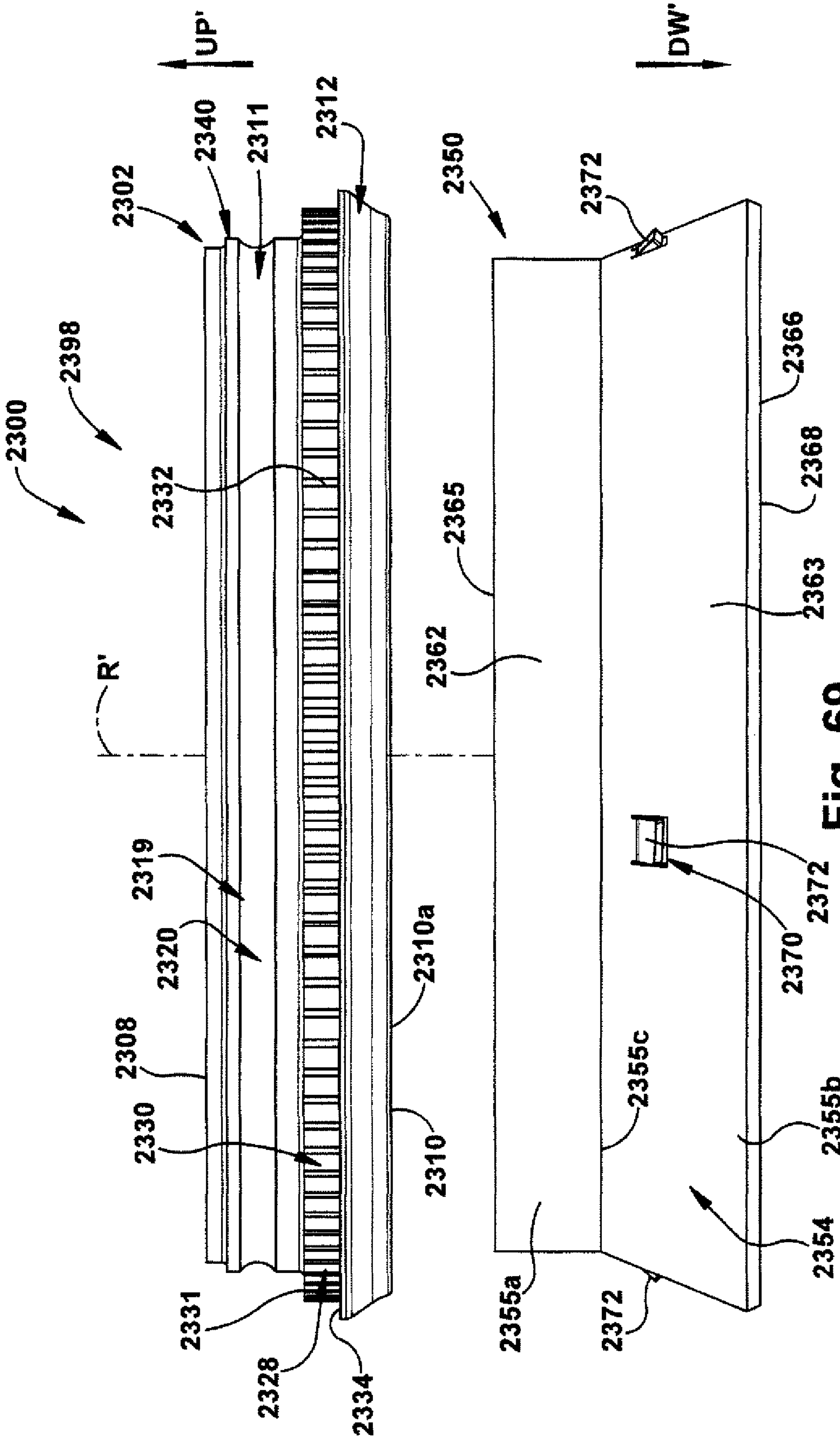

UP'
DW'
2300
2398
2302
2340
2311
2312
2350
2372
2332
2365
2366
2368
2363
2362
R'
2319
2320
2310a
2370
2372
2308
2330
2355c
2355b
2310
2354
2331
2355a
2372
2328
2334

Fig. 69

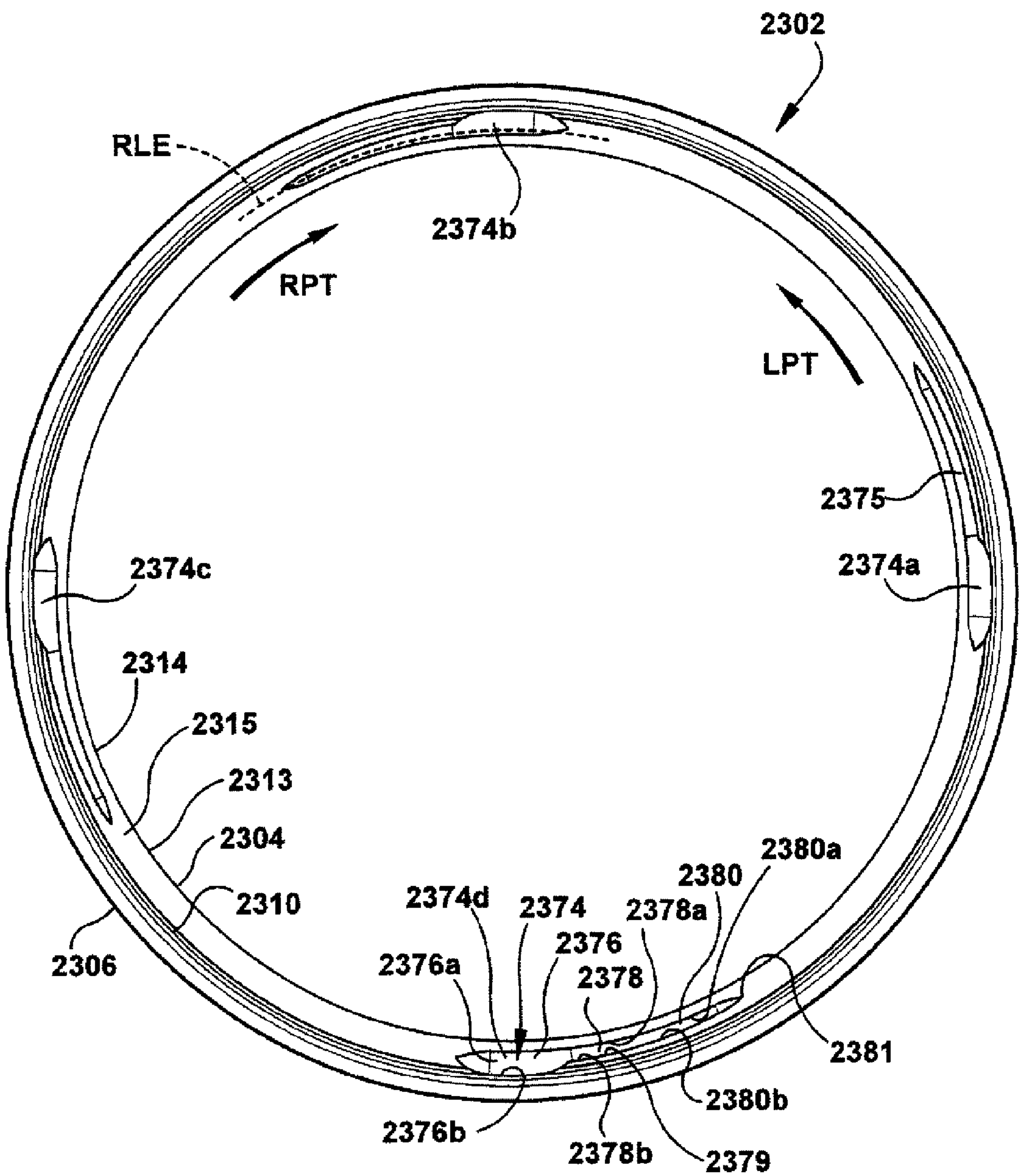

2302
RLE
2374b
RPT
LPT
2375
2374a
2374c
2314
2315
2313
2304
2310
2306
2380a
2380
2374d
2374
2378a
2376
2376a
2378
2381
2380b
2376b
2378b
2379

Fig. 70

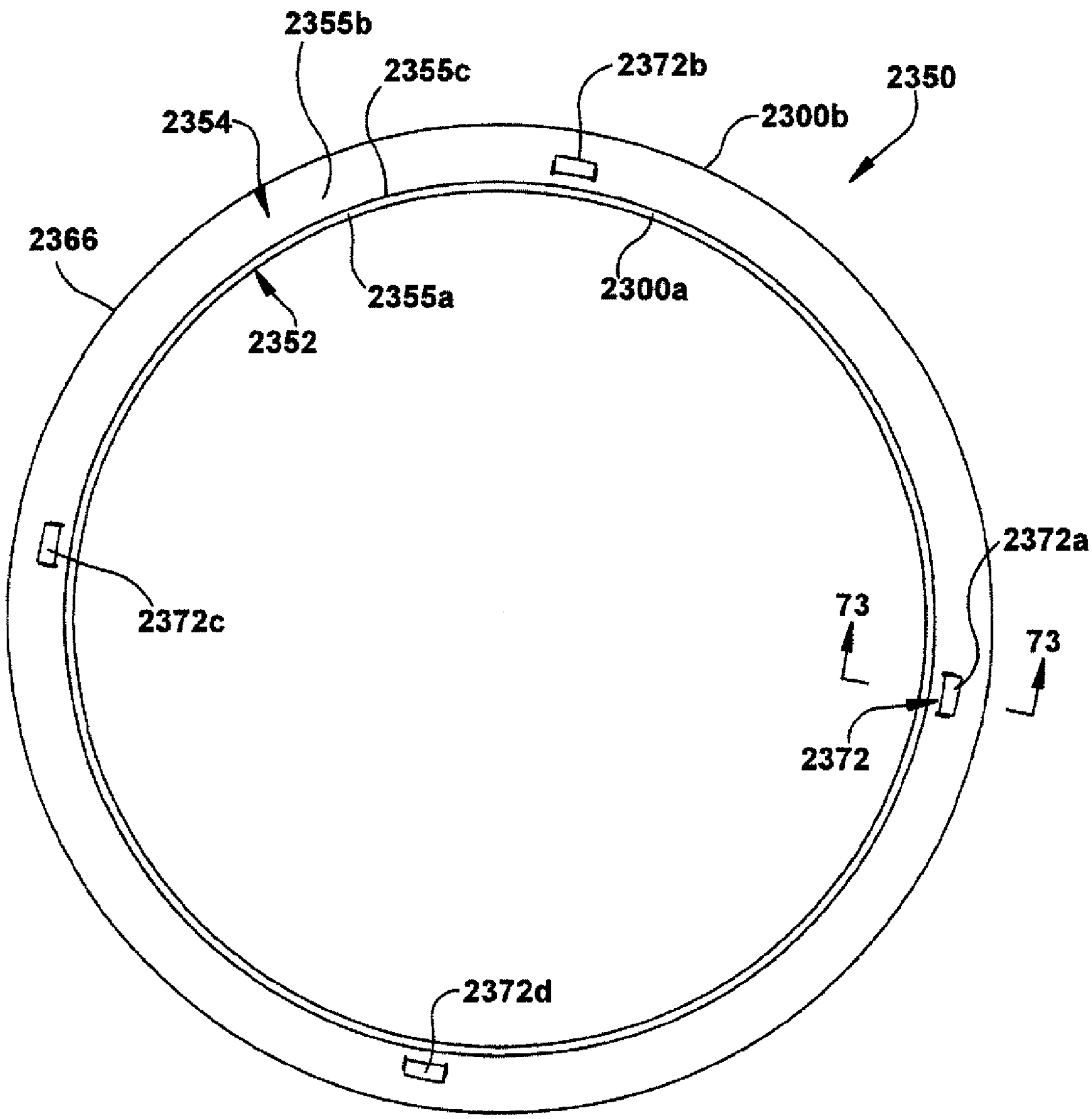

2355b
2355c
2372b
2350
2354
2300b
2366
2355a
2300a
2352
2372a
2372c
73
73
2372
2372d

Fig. 71

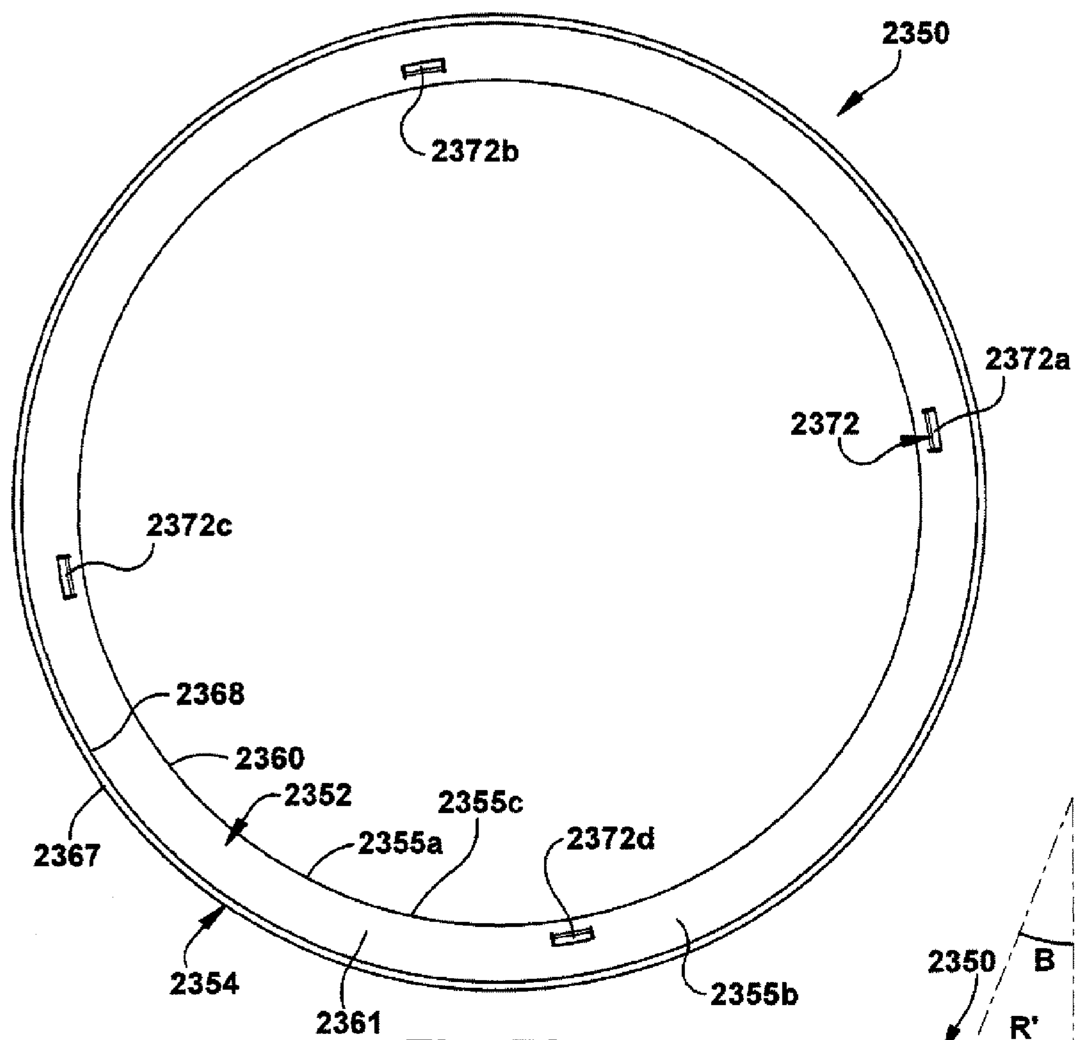

2350
2372b
2372a
2372
2372c
2368
2360
2352
2355c
2367
2355a
2372d
2354
2361
2355b

Fig. 72

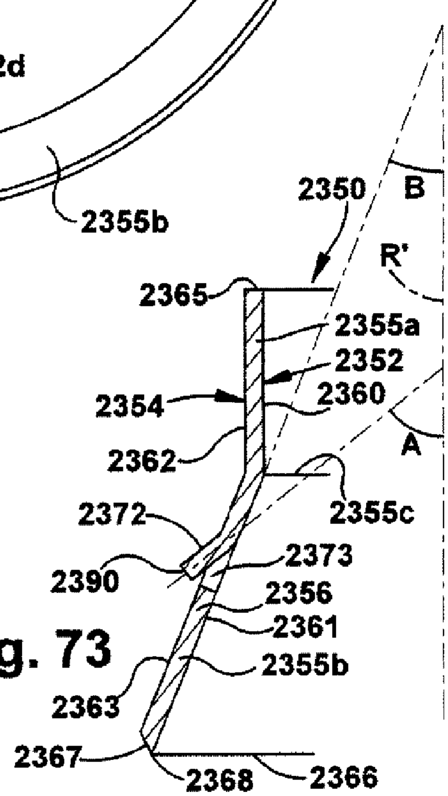

B
2350
R'
2365
2355a
2352
2360
2354
A
2362
2355c
2372
2373
2390
2356
2361
2355b
2363
2367
2368
2366

Fig. 73

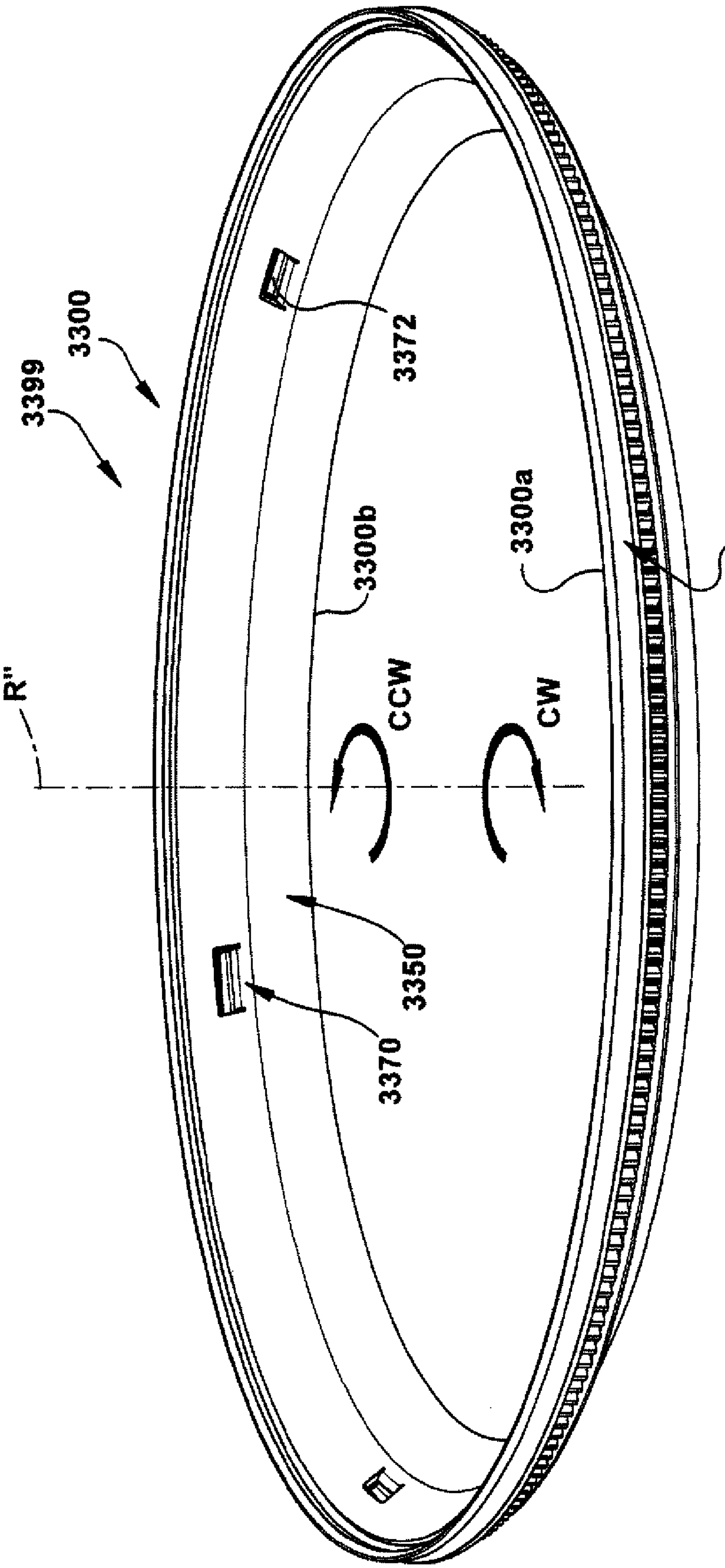


Fig. 74

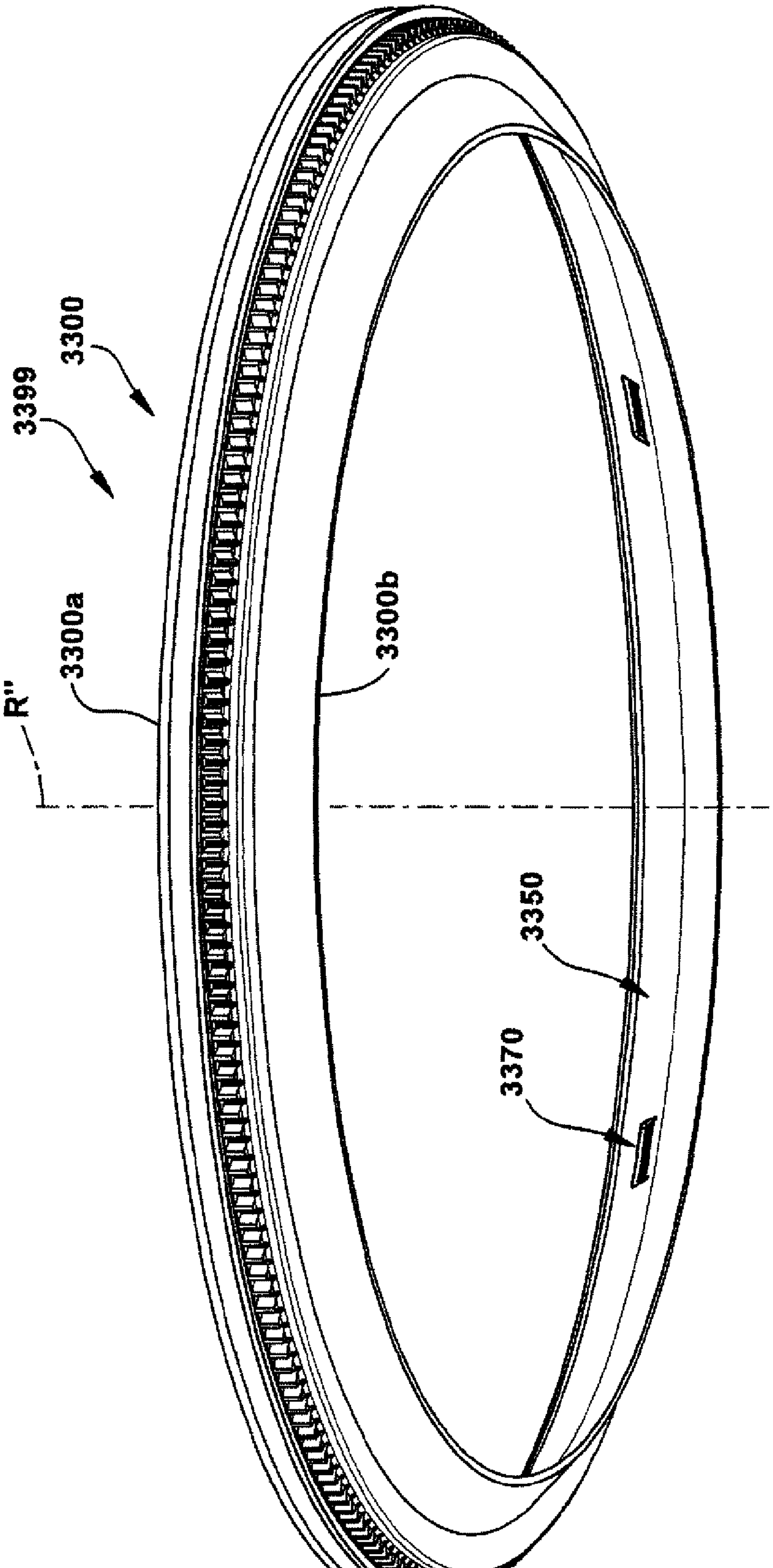


Fig. 75

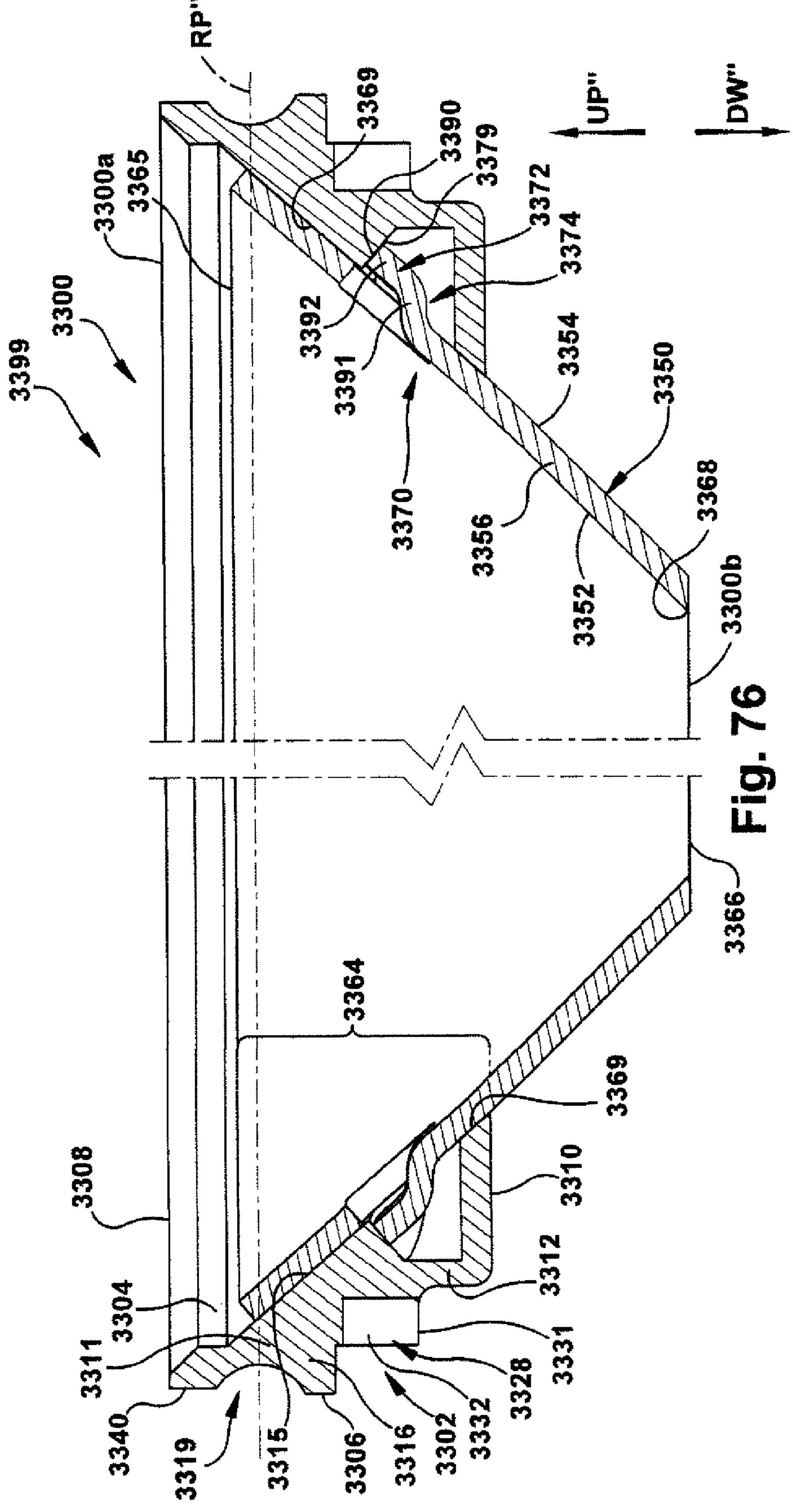

RP''
UP''
DW''
3399
3300
3300a
3365
3369
3390
3379
3372
3374
3392
3391
3370
3354
3350
3356
3352
3368
3300b
3366
3364
3369
3308
3310
3312
3331
3331
3328
3332
3302
3316
3306
3315
3319
3340
3311
3304

Fig. 76

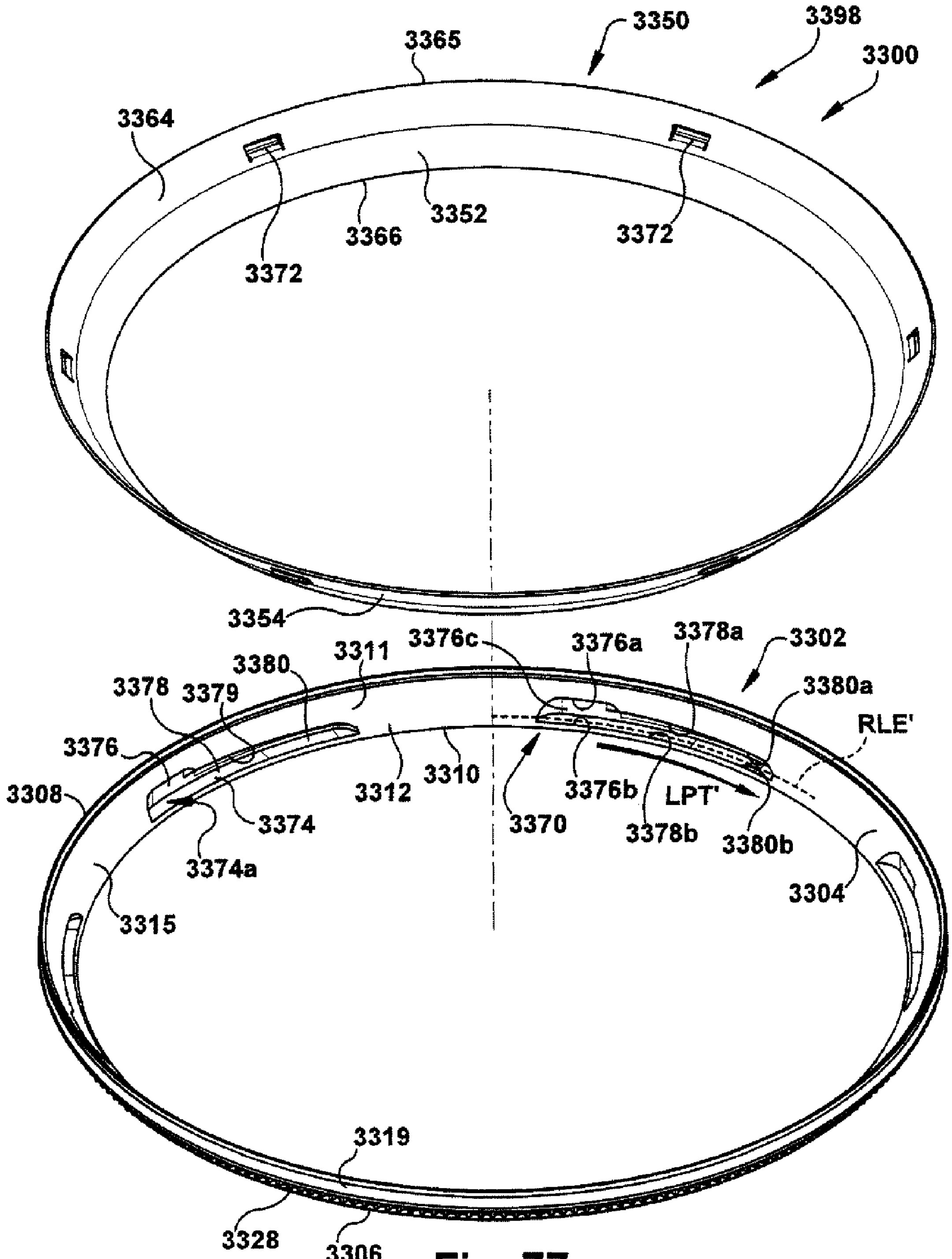

3350
3398
3300
3365
3364
3372
3366
3352
3372
3354
3376c
3376a
3378a
3302
3311
3380
3380a
3378
3379
RLE'
3376
3308
3312
3310
3370
3376b
LPT'
3374
3374a
3378b
3380b
3304
3315
3319
3328
3306

Fig. 77

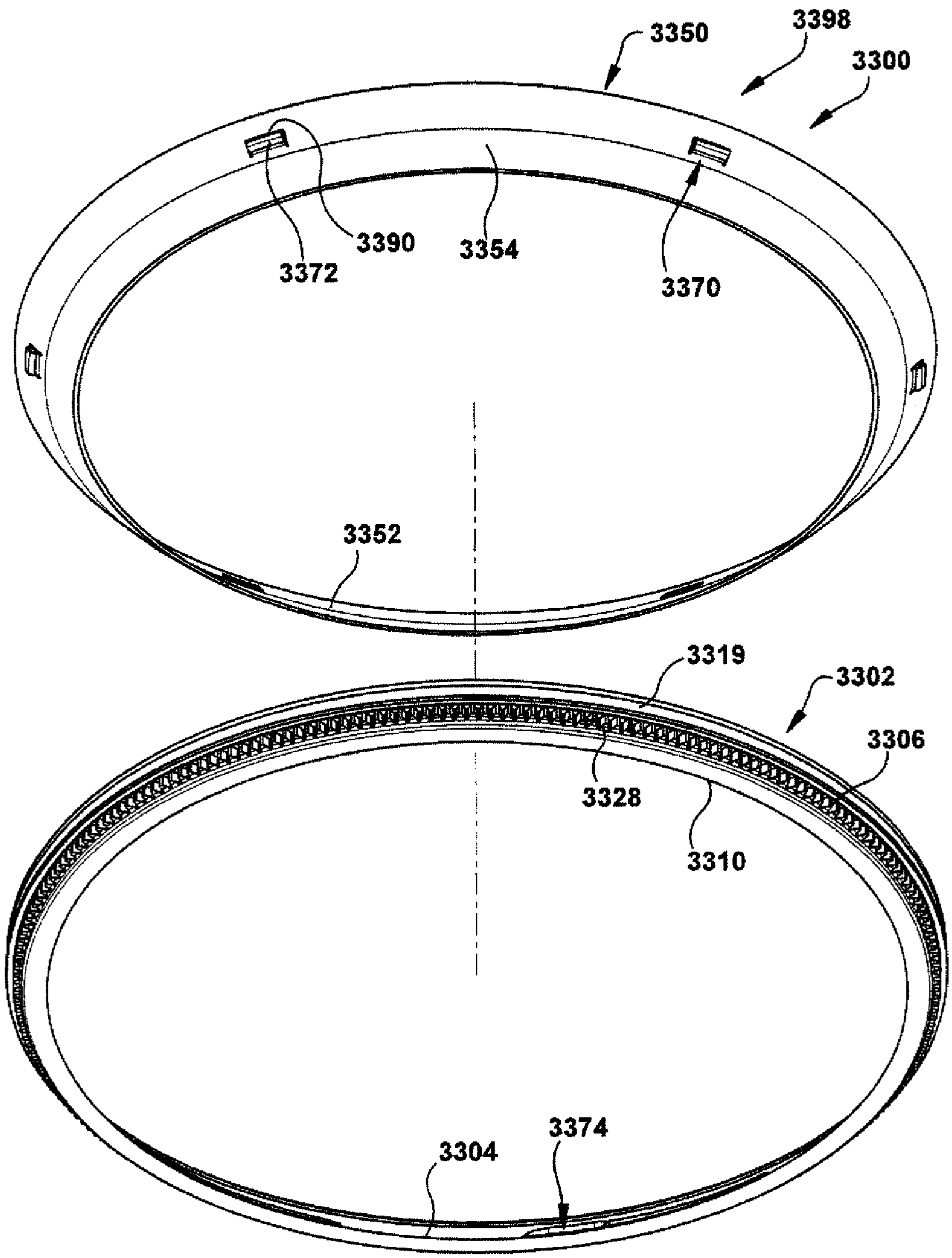

3350
3398
3300
3390
3372
3354
3370
3352
3319
3302
3306
3328
3310
3374
3304

Fig. 78

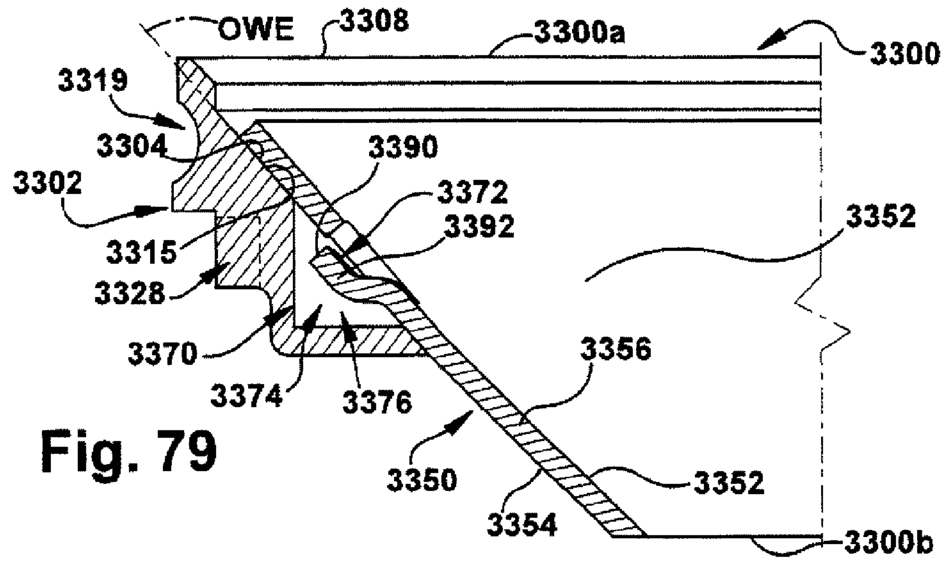


Fig. 79

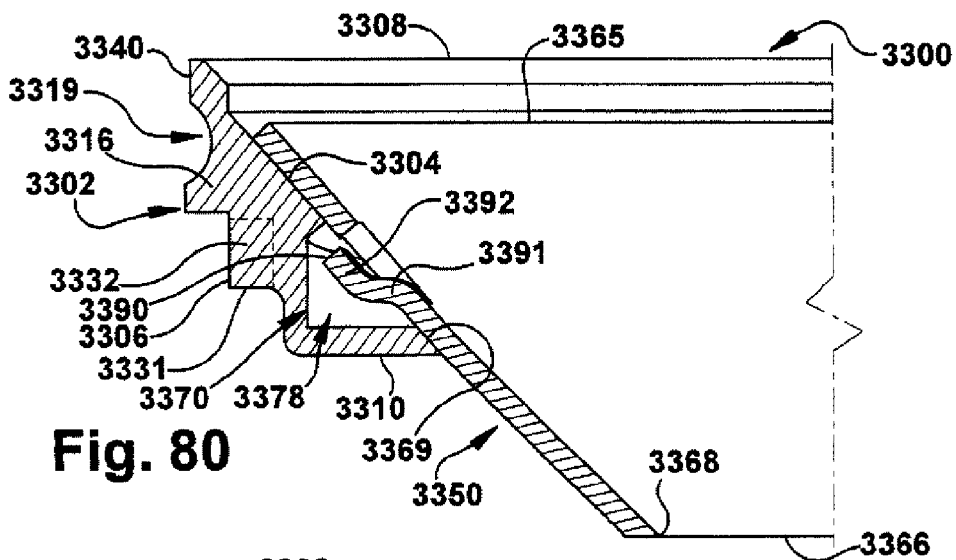


Fig. 80

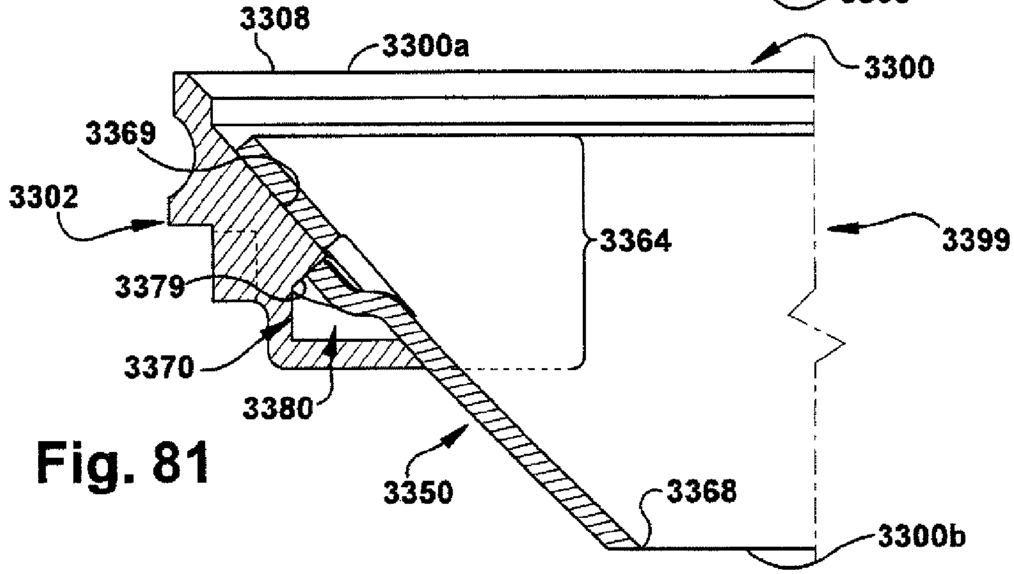


Fig. 81

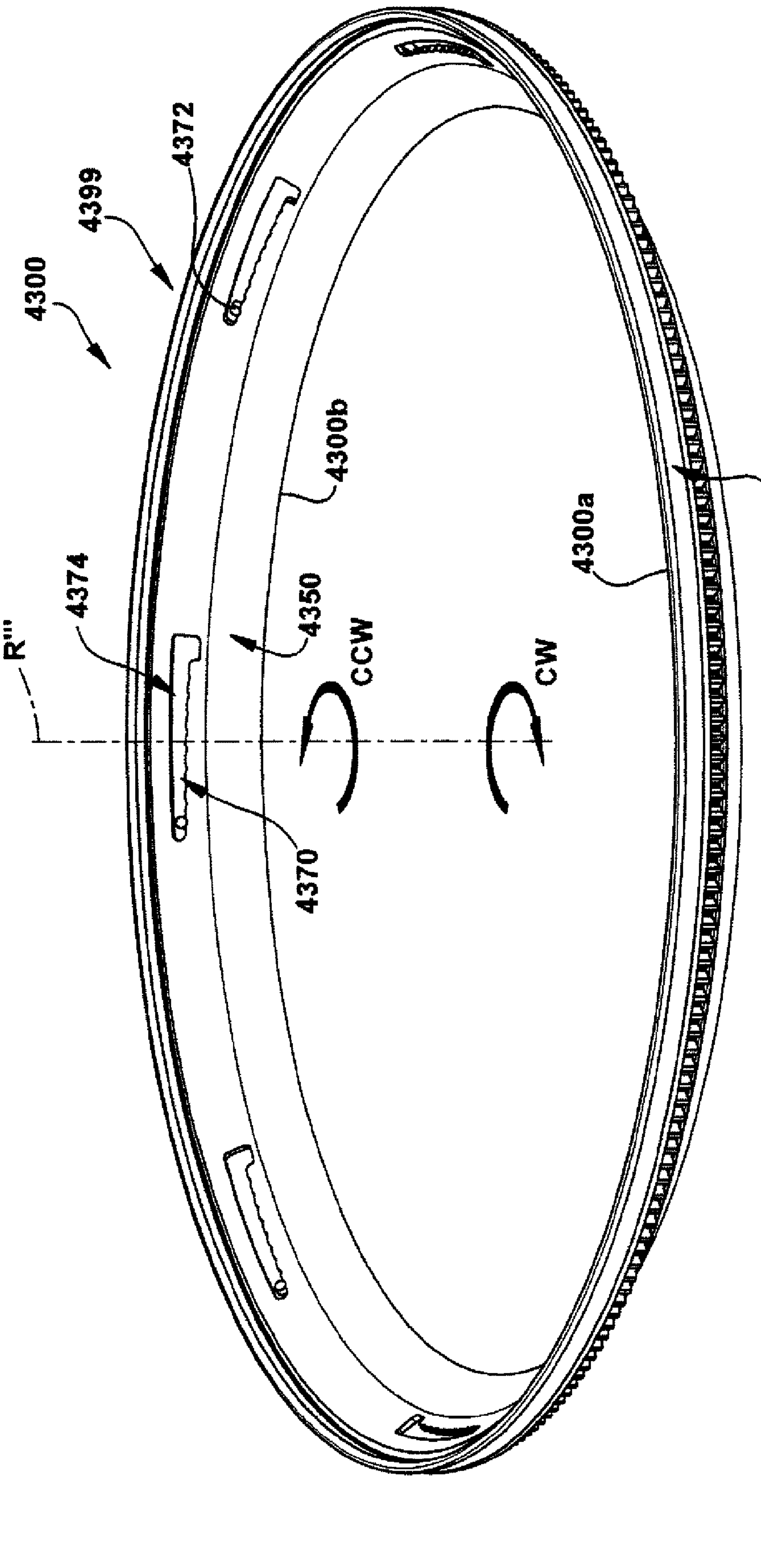


Fig. 82

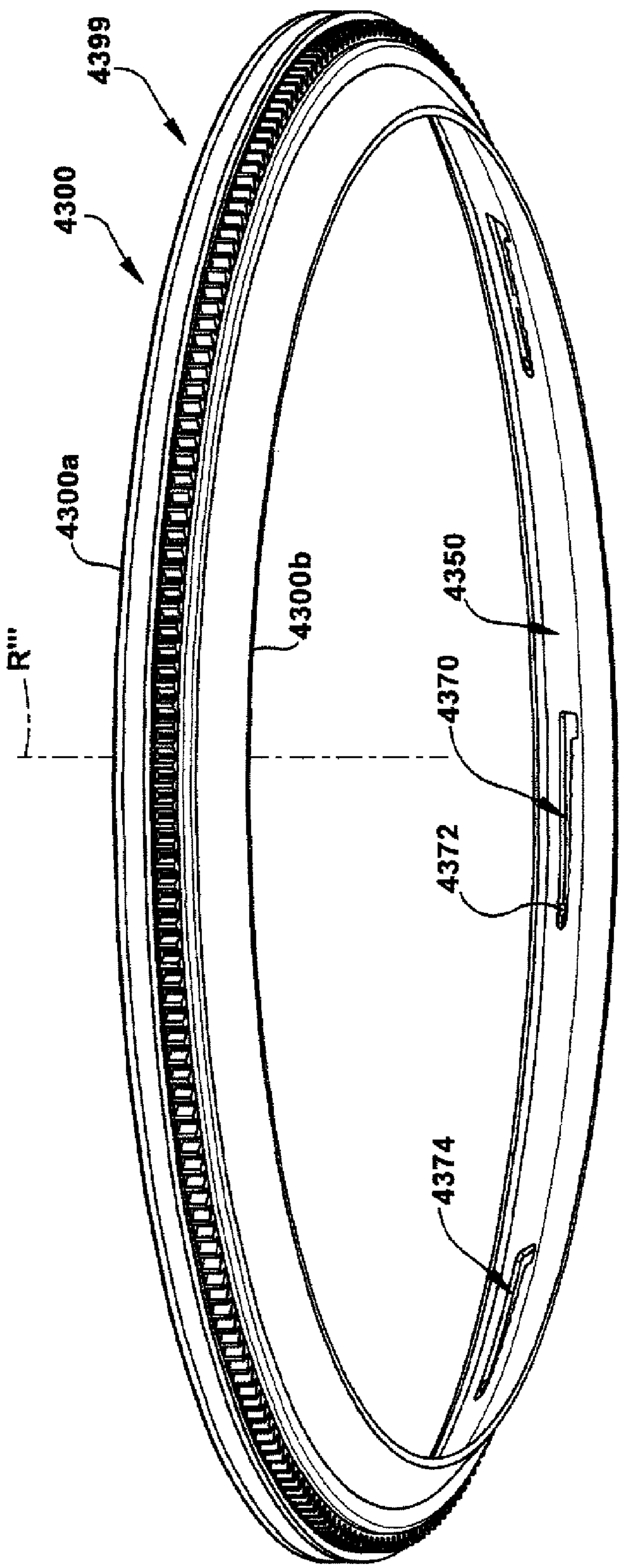

4399
4300
4300a
4300b
R'''
4350
4370
4372
4374

Fig. 83

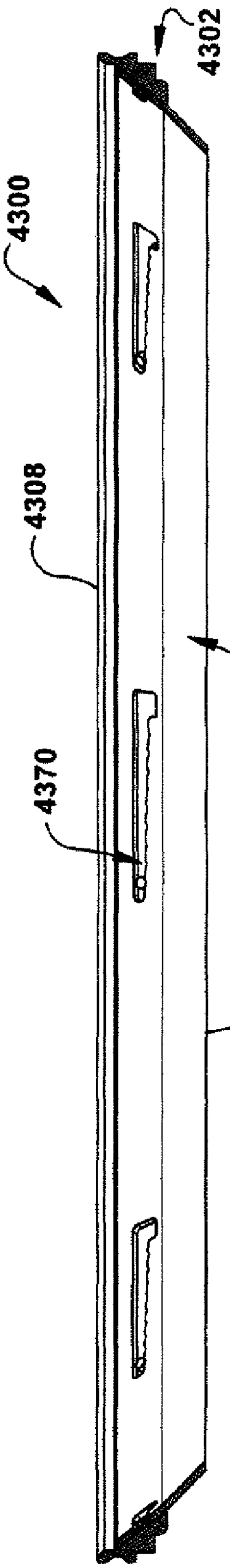

4302
4300
4308
4350
4370
4310

Fig. 84

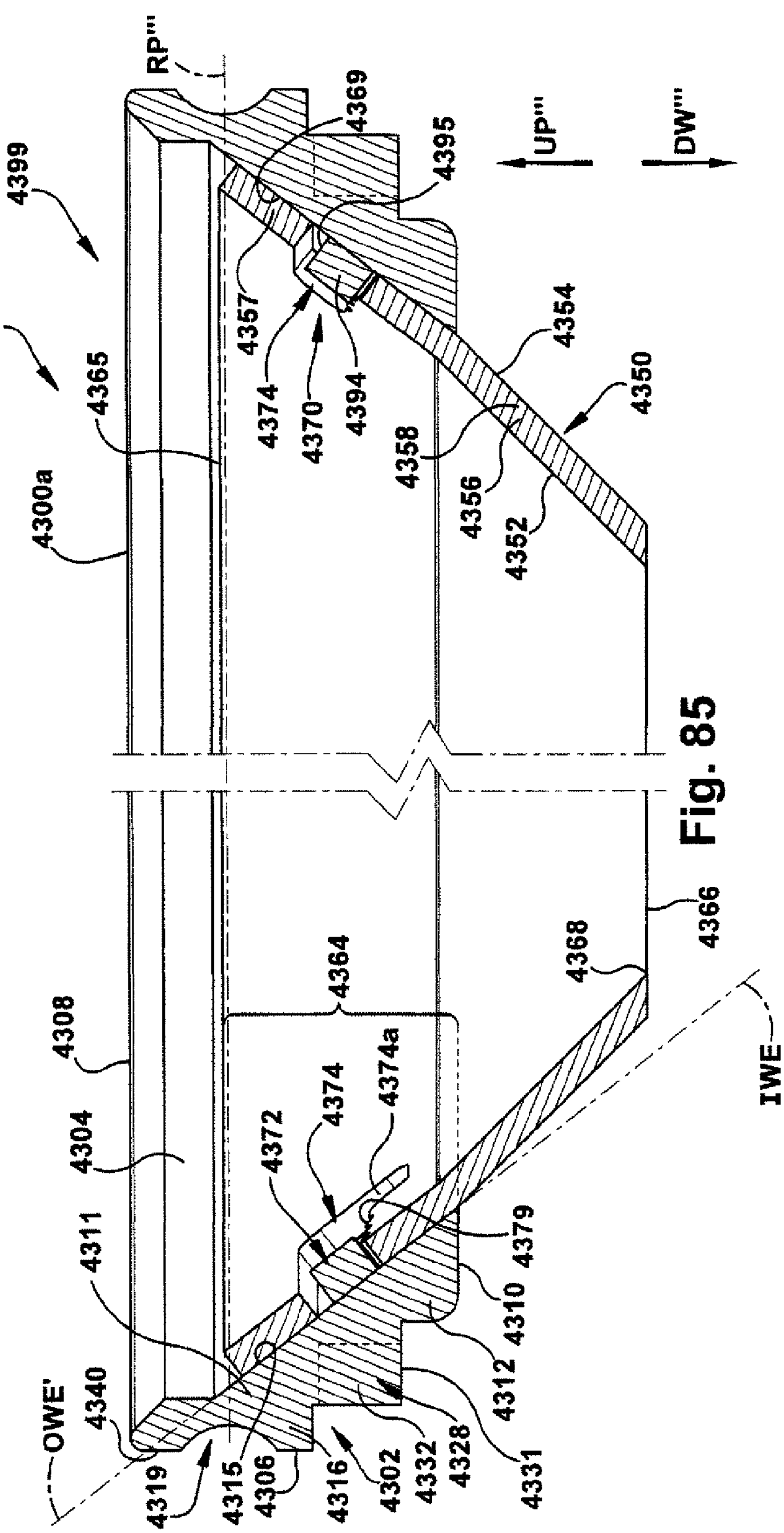

RP'''
4369
4395
UP'''
DW'''
4399
4300
4357
4374
4370
4394
4365
4354
4350
4358
4356
4352
4300a
4366
4368
4364
4308
4374
4374a
4372
4304
4311
4379
4310
4312
4331
4328
4332
4302
4316
4306
4315
4319
4340
OWE'
IWE

Fig. 85

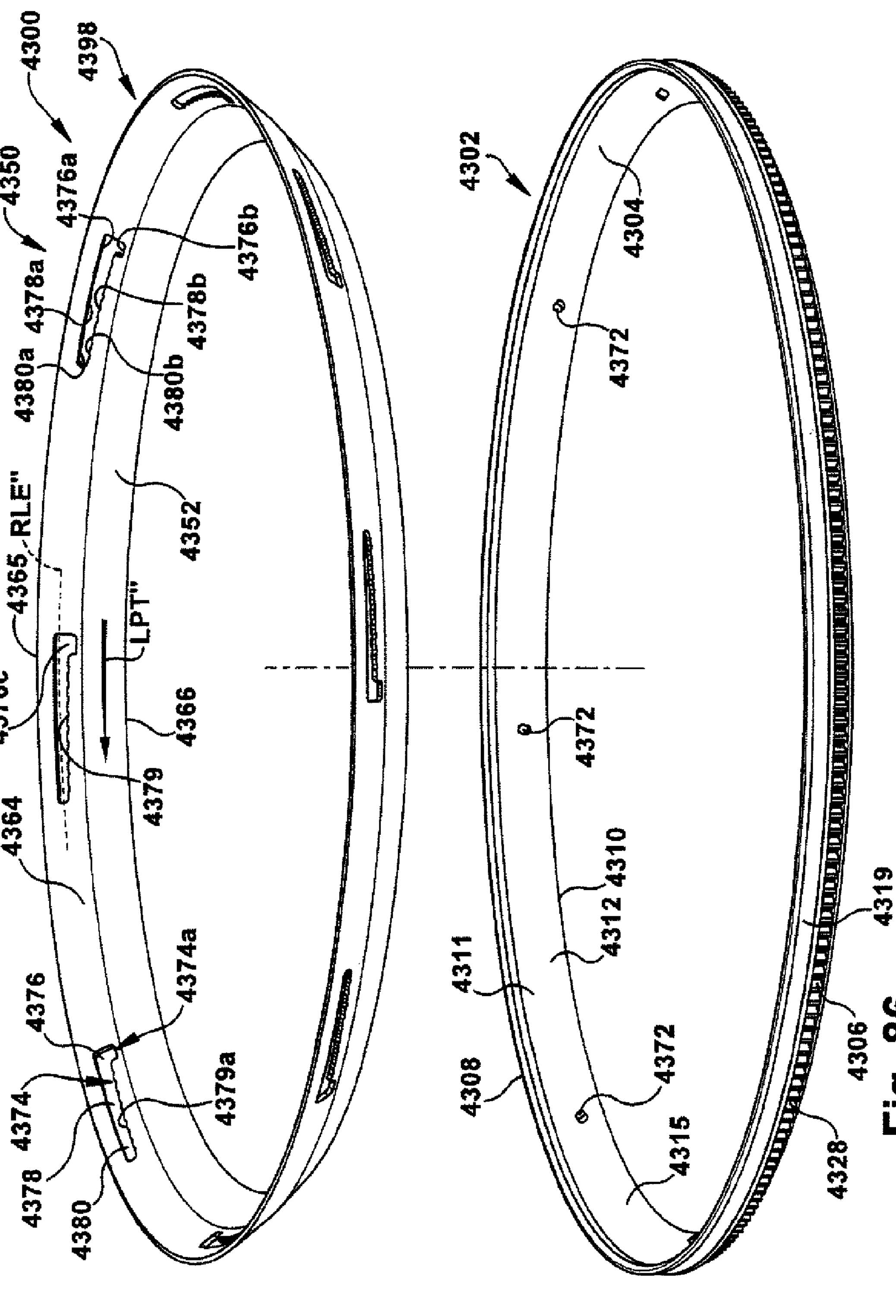

4300
4398
4350
4376a
4376b
4378a
4378b
4380a
4380b
4352
RLE"
4365
LPT"
4376c
4366
4379
4364
4376
4374a
4374
4379a
4378
4380
4302
4304
4372
4372
4310
4312
4311
4319
4306
4308
4372
4315
4328

Fig. 86

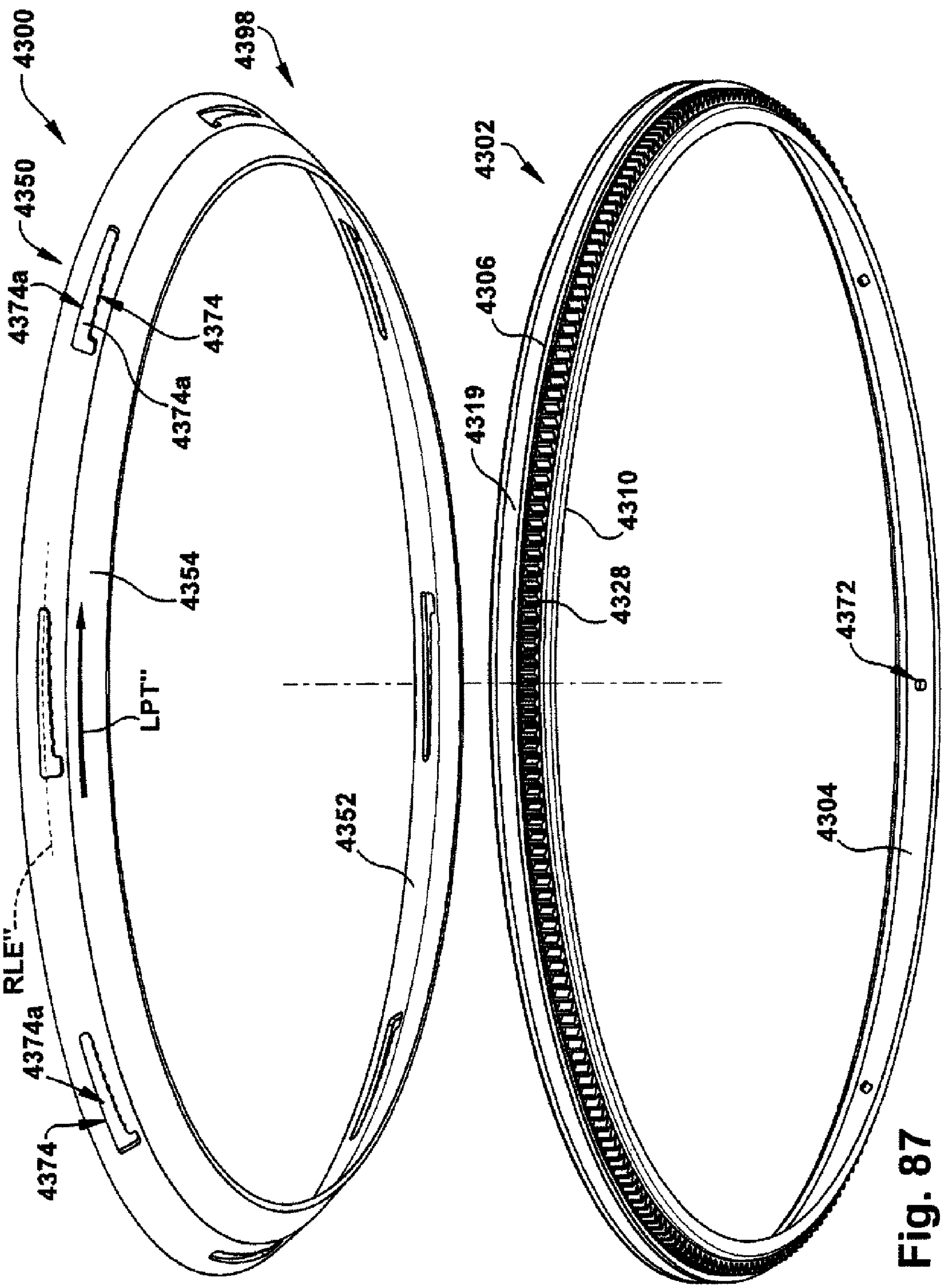

4300
4398
4350
4302
4374a
4374
4374a
4306
4319
4310
4354
4328
4372
LPT''
RLE''
4352
4304
4374a
4374

Fig. 87

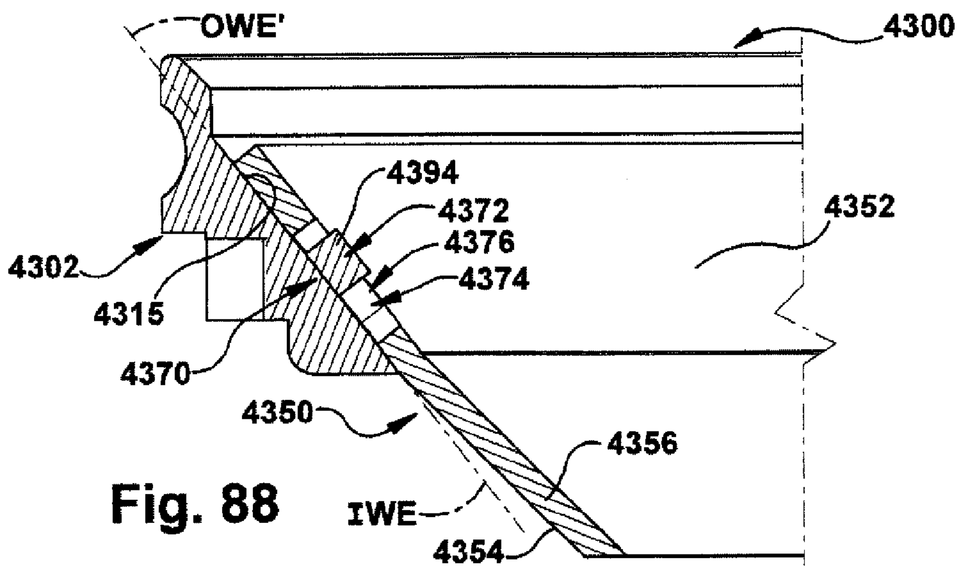


Fig. 88

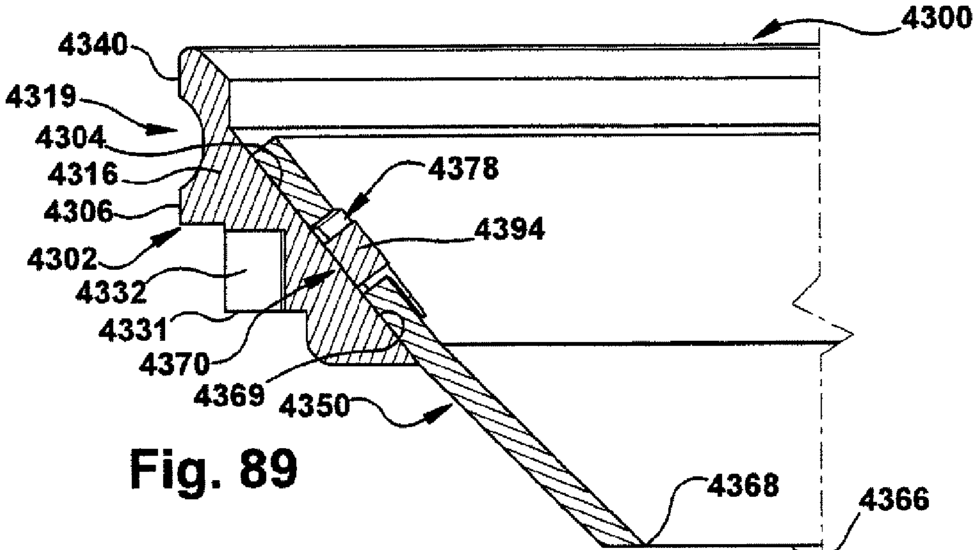


Fig. 89

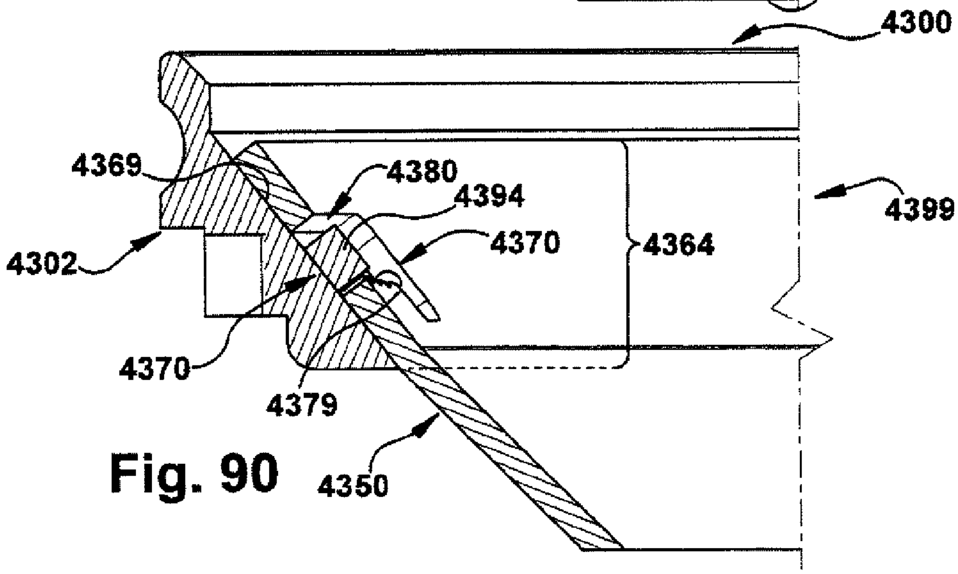


Fig. 90

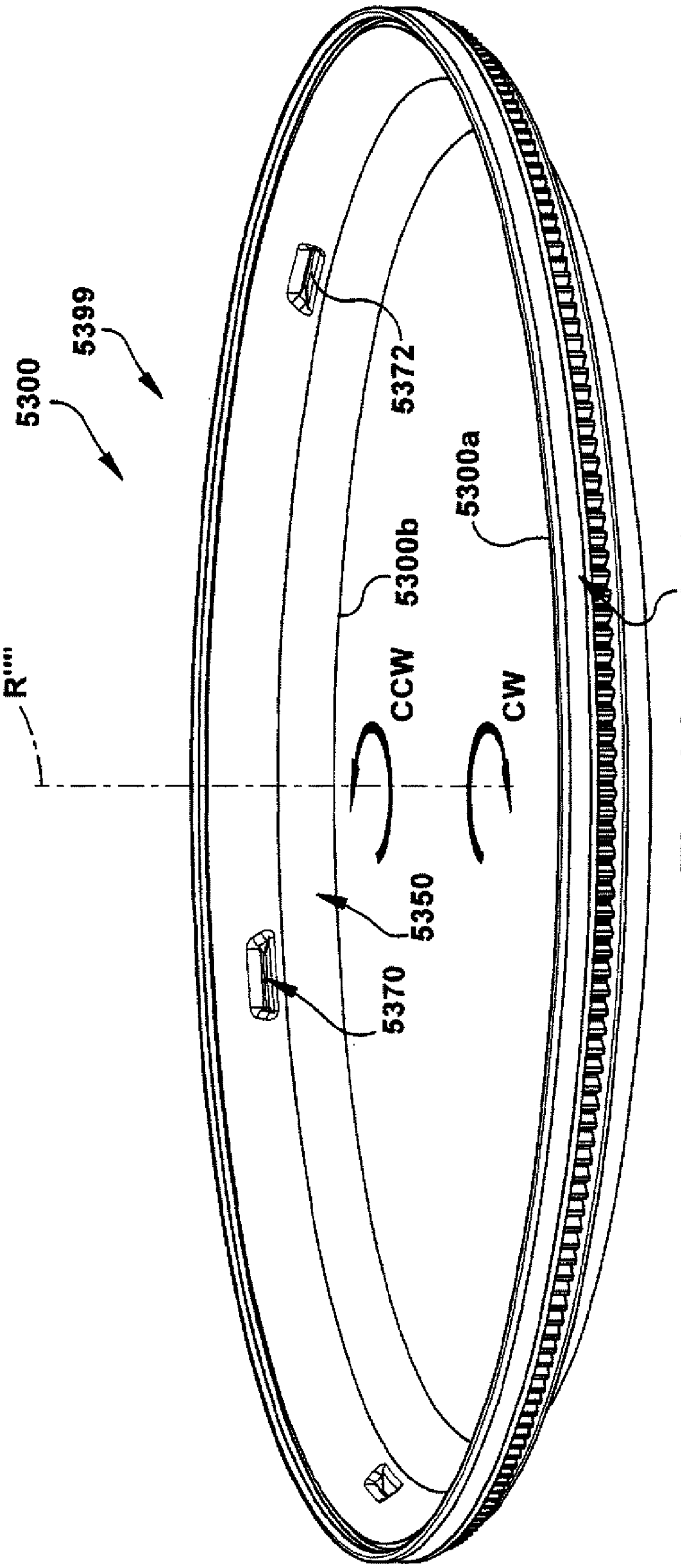


Fig. 91

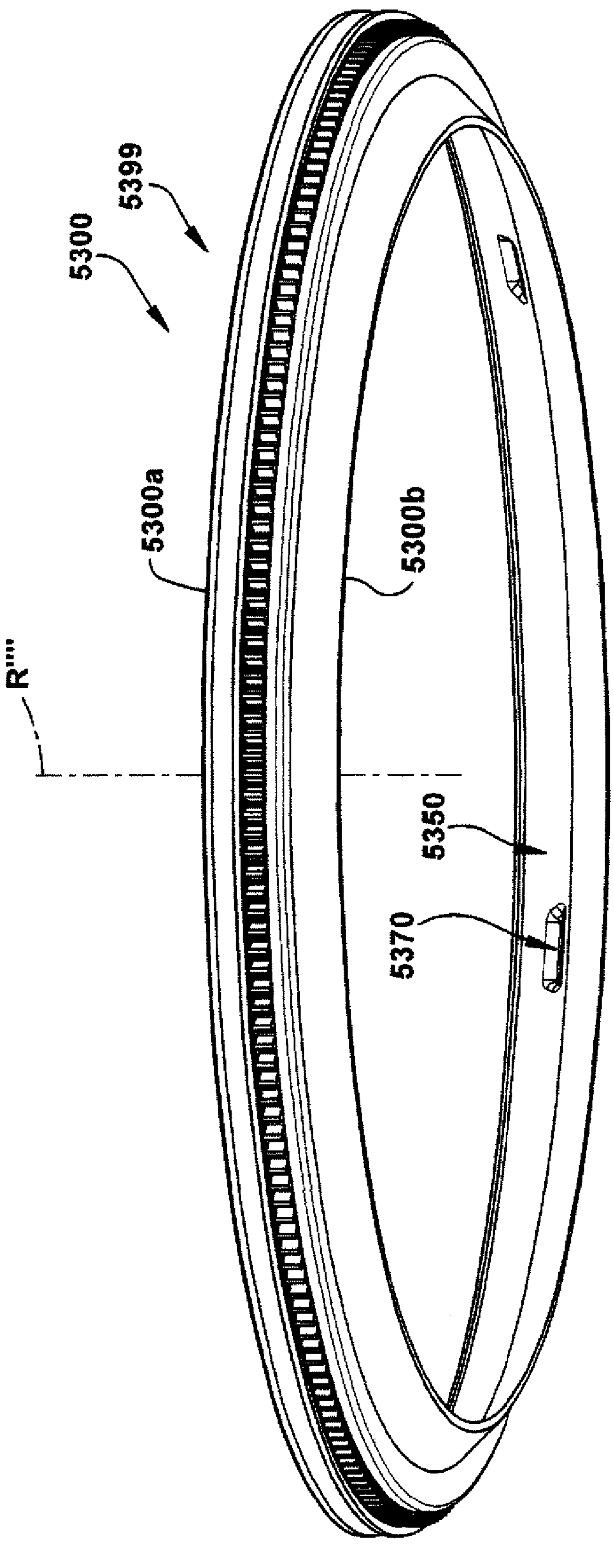


Fig. 92

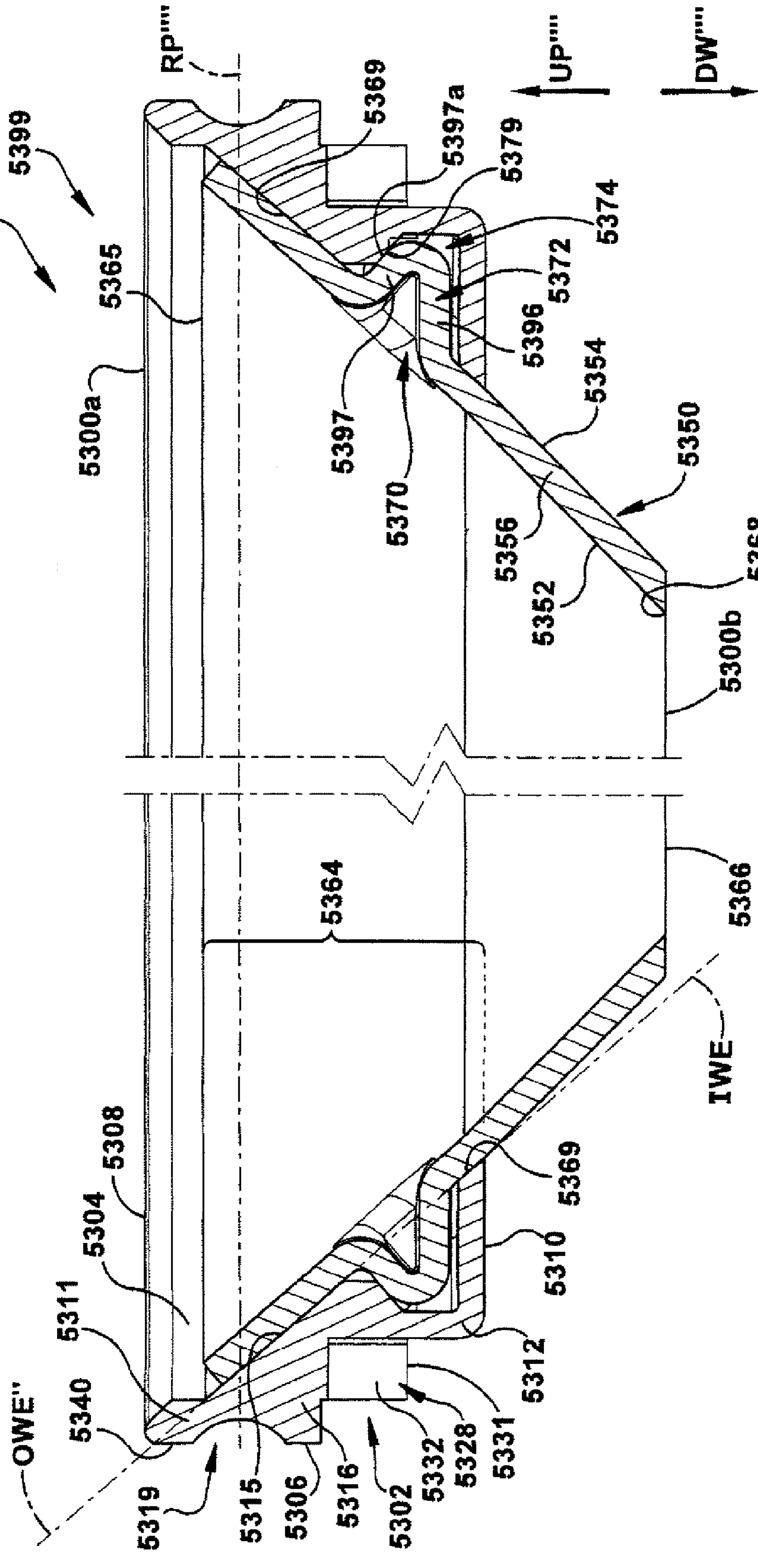

RP''''
UP''''
DW''''
5300
5399
5365
5300a
5369
5397a
5379
5374
5372
5396
5354
5397
5370
5350
5356
5352
5368
5300b
5364
5366
IWE
5308
5304
5311
5340
OWE''
5319
5315
5306
5316
5302
5332
5328
5331
5312
5310
5369

Fig. 93

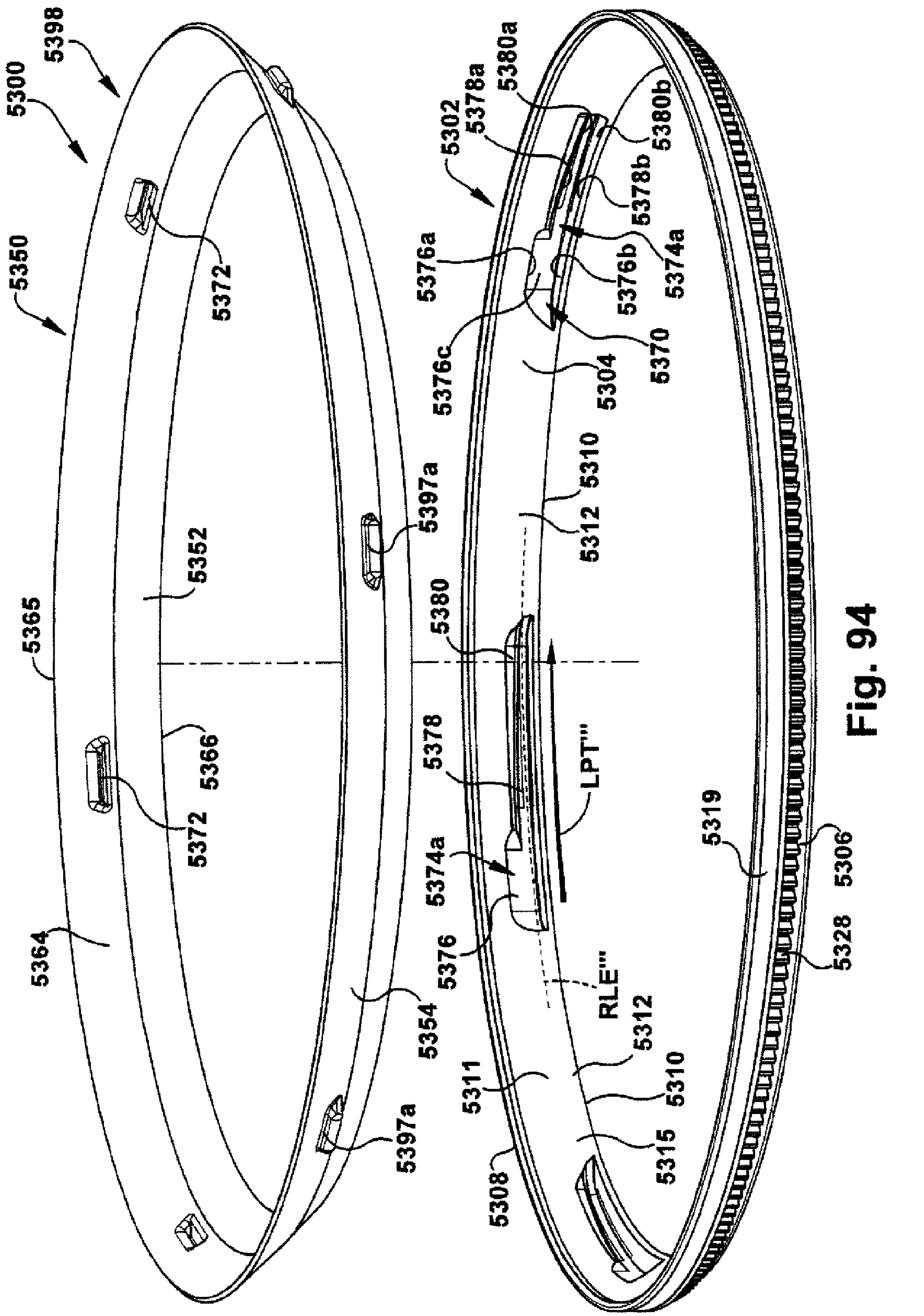

5300
5398
5350
5372
5397a
5352
5365
5366
5364
5354
5302
5378a
5380a
5380b
5378b
5374a
5376a
5376b
5370
5376c
5304
5310
5312
5380
5378
LPT'''
5376
RLE'''
5311
5315
5308
5319
5306
5328

Fig. 94

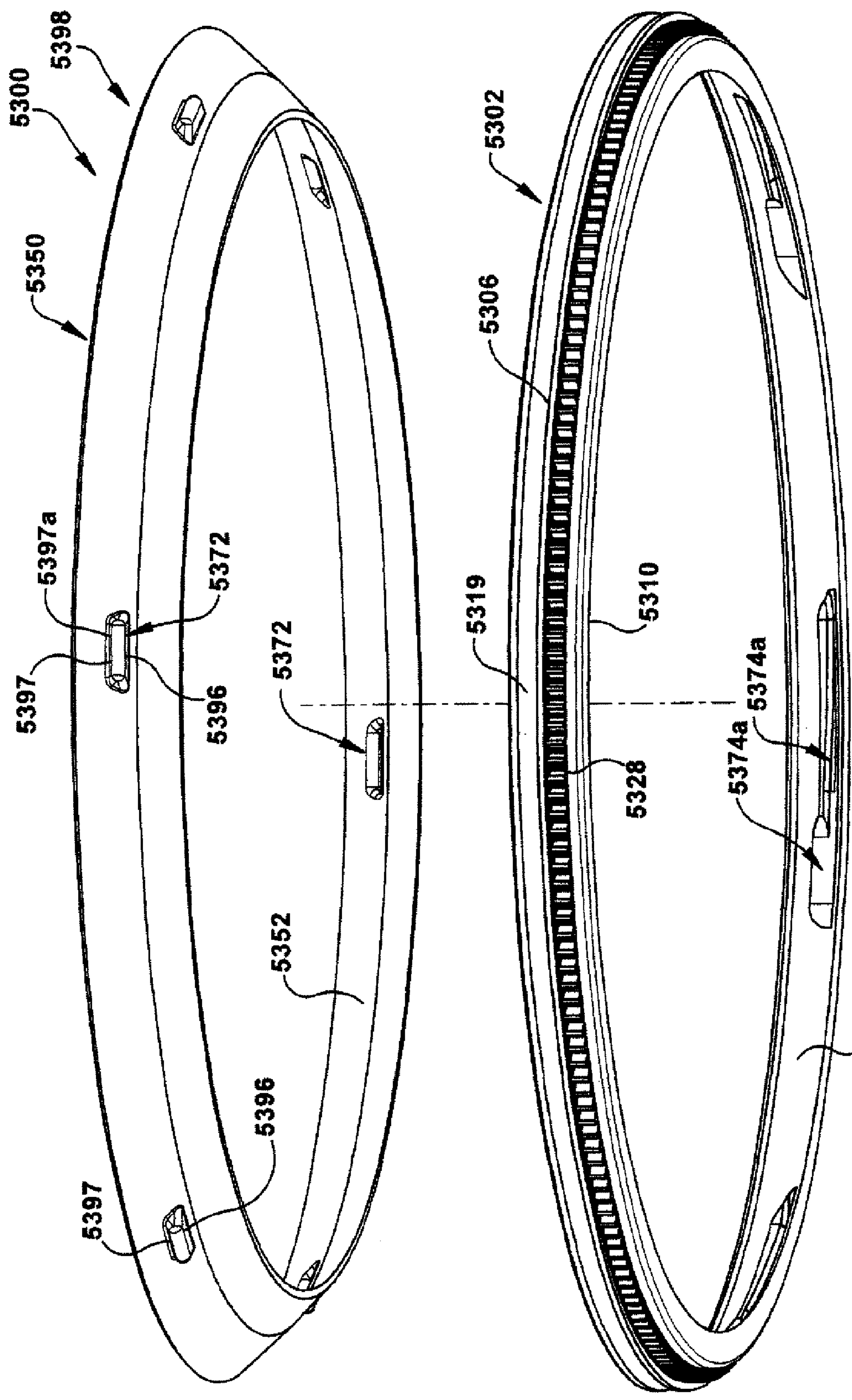

5300
5398
5350
5397a
5372
5397
5396
5372
5352
5396
5397
5302
5306
5319
5310
5328
5374a
5374a
5374a
5304

Fig. 95

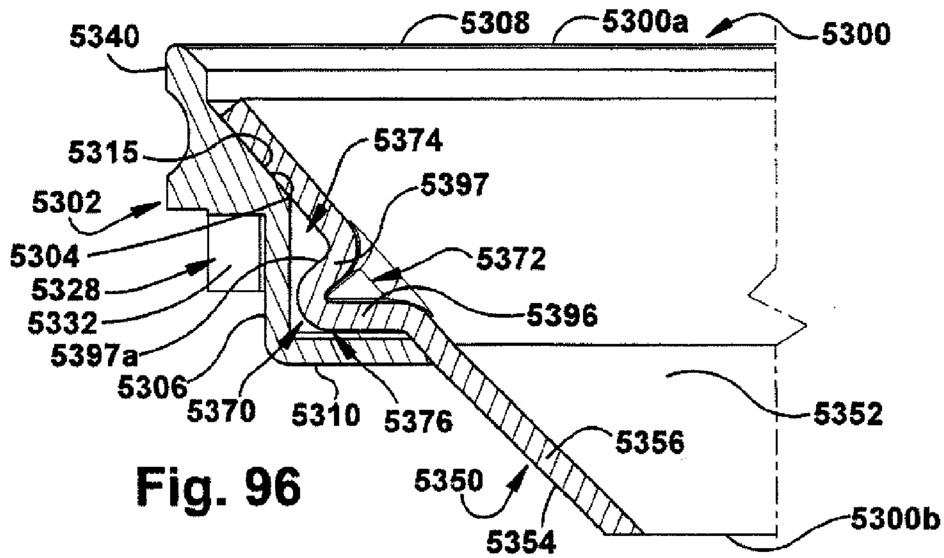


Fig. 96

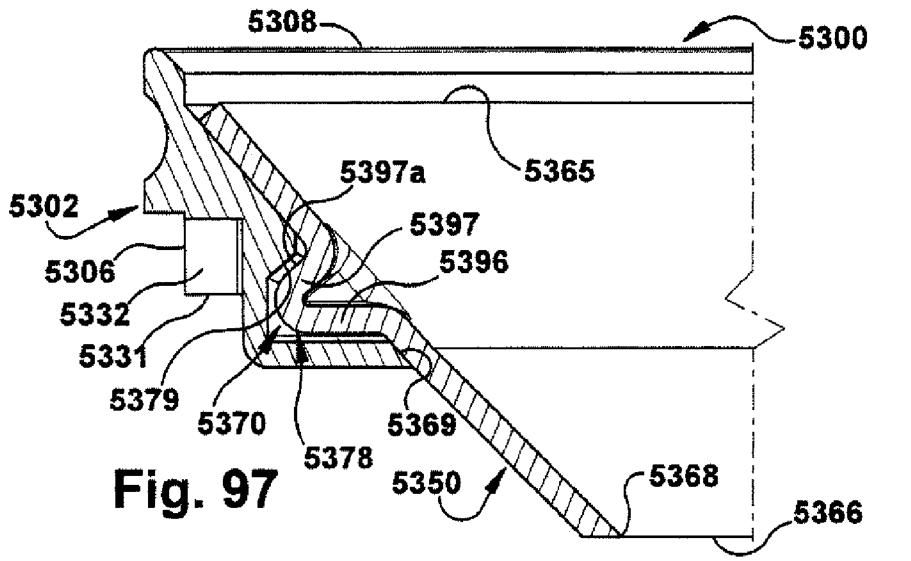


Fig. 97

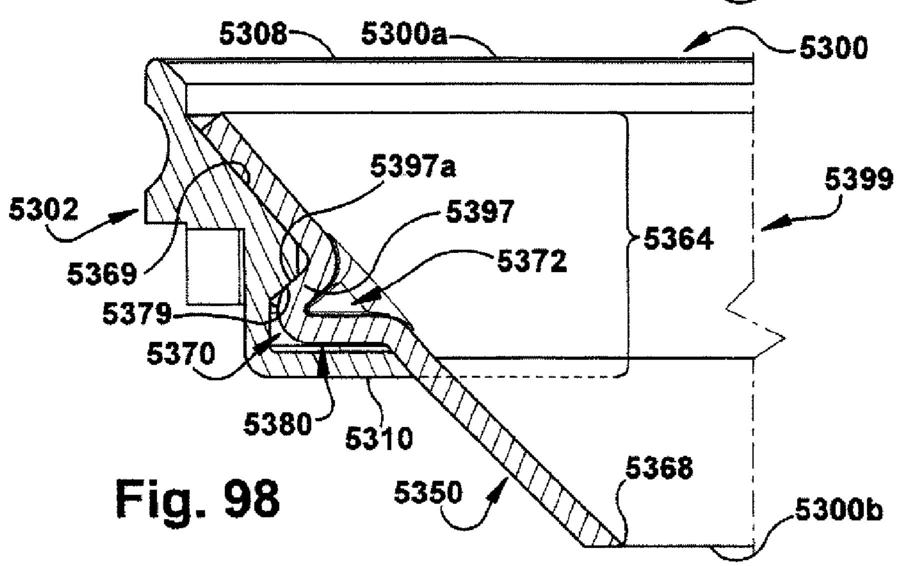


Fig. 98

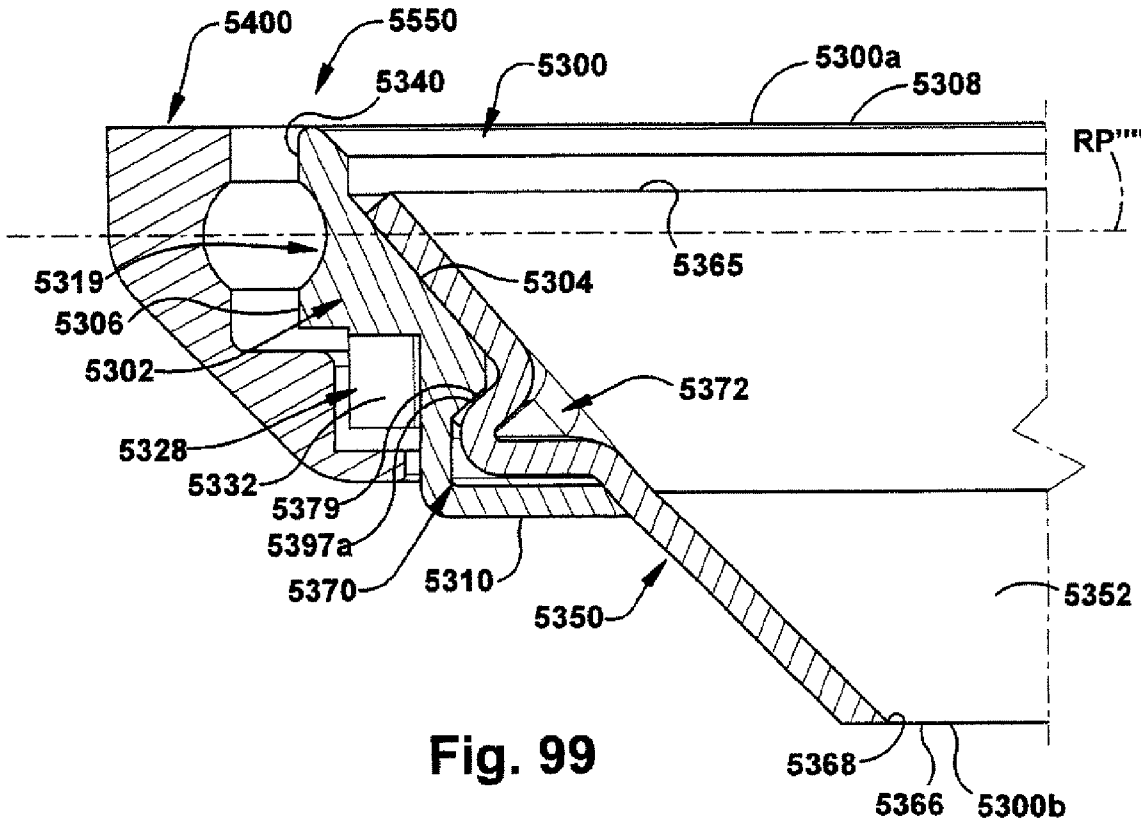

5400
5550
5340
5300
5300a
5308
RP''''
5365
5319
5304
5306
5302
5372
5328
5332
5379
5397a
5370
5310
5350
5352
5368
5366
5300b

Fig. 99

POWER OPERATED ROTARY KNIFE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and is a continuation of U.S. application Ser. No. 13/556,008, filed on Jul. 23, 2012, published as U.S. Publication No. US-2013-0185944-A1 on Jul. 25, 2013, issuing as U.S. Pat. No. 8,745,881 on Jun. 10, 2014, which is a continuation-in-part of U.S. application Ser. No. 13/189,938, filed on Jul. 25, 2011, published as U.S. Publication No. US-2013-025138-A1 on Jan. 31, 2013, issued as U.S. Pat. No. 8,726,524 on May 20, 2014. U.S. application Ser. No. 13/556,008 and U.S. Publication No. US-2013-0185944-A1 and U.S. application Ser. No. 13/189,938 and U.S. Publication No. US-2013-0025138-A1 are incorporated herein in their respective entireties by reference for any an all purposes.

TECHNICAL FIELD

The present disclosure relates to a power operated rotary knife.

BACKGROUND

Power operated rotary knives are widely used in meat processing facilities for meat cutting and trimming operations. Power operated rotary knives also have application in a variety of other industries where cutting and/or trimming operations need to be performed quickly and with less effort than would be the case if traditional manual cutting or trimming tools were used, e.g., long knives, scissors, nippers, etc. By way of example, power operated rotary knives may be effectively utilized for such diverse tasks as taxidermy and cutting and trimming of elastomeric or urethane foam for a variety of applications including vehicle seats.

Power operated rotary knives typically include a handle assembly and a head assembly attachable to the handle assembly. The head assembly includes an annular blade housing and an annular rotary knife blade supported for rotation by the blade housing. The annular rotary blade of conventional power operated rotary knives is typically rotated by a drive assembly which include a flexible shaft drive assembly extending through an opening in the handle assembly. The shaft drive assembly engages and rotates a pinion gear supported by the head assembly. The flexible shaft drive assembly includes a stationary outer sheath and a rotatable interior drive shaft which is driven by a pneumatic or electric motor. Gear teeth of the pinion gear engage mating gear teeth formed on an upper surface of the rotary knife blade.

Upon rotation of the pinion gear by the drive shaft of the flexible shaft drive assembly, the annular rotary blade rotates within the blade housing at a high RPM, on the order of 900-1900 RPM, depending on the structure and characteristics of the drive assembly including the motor, the shaft drive assembly, and a diameter and the number of gear teeth formed on the rotary knife blade. Conventional power operated rotary knives are disclosed in U.S. Pat. No. 6,354,949 to Baris et al., U.S. Pat. No. 6,751,872 to Whited et al., U.S. Pat. No. 6,769,184 to Whited, and U.S. Pat. No. 6,978,548 to Whited et al., all of which are assigned to the assignee of the present invention and all of which are incorporated herein in their respective entireties by reference.

SUMMARY

In one aspect, the present disclosure relates a power operated rotary knife comprising: an annular rotary knife blade

including a wall defining a knife blade bearing surface; a blade housing including a wall defining a blade housing bearing surface; and a blade-blade housing bearing structure disposed between the knife blade bearing surface and the blade housing bearing surface, the blade-blade housing bearing structure supporting the knife blade for rotation with respect to the blade housing about a knife blade central axis, the blade-blade housing bearing structure including an elongated rolling bearing strip that extends circumferentially around the knife blade central axis between the knife blade bearing surface and the blade housing bearing surface. In one exemplary embodiment, the elongated rolling bearing strip comprises a plurality of rolling bearings disposed in spaced apart relation and a flexible separator cage for positioning the plurality of spaced apart rolling bearings.

In another aspect, the present disclosure relates to a support structure for use with a power operated rotary knife including an annular rotary knife blade rotating about a central axis and an annular blade housing, the support structure disposed between a knife blade bearing surface and a blade housing bearing surface to secure and rotatably support the knife blade with respect to the blade housing, the support structure comprising: an elongated rolling bearing strip having a plurality of rolling bearings disposed in spaced apart relation and a flexible separator cage for positioning the plurality of spaced apart rolling bearings, the rolling bearing strip extending circumferentially between the knife blade bearing surface and the blade housing bearing surface, the separator cage forming at least a portion of a circle and each of the plurality of rolling bearings extending radially from the separator cage and adapted to contact the knife blade bearing surface and the blade housing bearing surface.

In another aspect, the present disclosure relates to a method of supporting an annular knife blade for rotation about a central axis in a blade housing of a power operated rotary knife, the method comprising: aligning a knife blade and blade housing such that a bearing surface of the knife blade is in radial alignment with a bearing surface of the blade housing, the knife blade bearing surface and the blade housing bearing surface defining an annular passageway; and routing a rolling bearing strip along the annular passageway such that the strip extends circumferentially around the knife blade central axis between the knife blade bearing surface and the blade housing bearing surface forming at least a portion of a circle about the central axis.

In another aspect, the present disclosure relates to a power operated rotary knife comprising: a head assembly including a gearbox assembly, an annular rotary knife blade, a blade housing, and a blade-blade housing bearing structure; the blade housing coupled to the gearbox assembly and including an annular blade support section defining a bearing surface formed on an inner wall of the annular blade support section; the annular rotary knife blade including a body and a blade section extending axially from the body, the body including a first, upper end and a lower, second end spaced axially apart and an inner wall and an outer wall spaced radially apart, the blade section extending from the lower end of the body, the outer wall defining a knife blade bearing surface and a set of gear teeth, the set of gear teeth being axially spaced from the upper end of the body and from the knife blade bearing surface; the blade-blade housing bearing structure disposed between the knife blade bearing surface and the blade housing bearing surface; and a gear train of the gearbox assembly, the gear train including a drive gear having a plurality of gear teeth that mesh with the set of gear teeth of the knife blade to rotate the knife blade with respect to the blade housing.

In another aspect, the present disclosure relates to an annular rotary knife blade for rotation about a central axis in a power operated rotary knife, the rotary knife blade comprising: an annular rotary knife blade including a body and a blade section extending axially from the body, the body including a first upper end and a second lower end spaced axially apart and an inner wall and an outer wall spaced radially apart; the blade section extending from the lower end of the body; and the outer wall defining a knife blade bearing surface and a set of gear teeth, the set of gear teeth being axially spaced from the upper end of the body and axially spaced from the knife blade bearing surface.

In another aspect, the present disclosure relates to a power operated rotary knife comprising: a gearbox assembly including a gearbox housing and a gearbox; a blade housing coupled to the gearbox housing; and an annular rotary knife blade including an upper end and an axially spaced apart lower end, the lower end defining a cutting edge of the blade, the knife blade further including an outer wall defining a set of gear teeth, the set of gear teeth being axially spaced from the upper end of the knife blade, the knife blade rotating about a central axis with respect to the blade housing; the gearbox comprising a gear train including a pinion gear and a drive gear, the pinion gear engaging and rotating the drive gear and the drive gear engaging and rotating the knife blade about the central axis; and the drive gear comprising a double gear including a first gear engaging and being rotated by the pinion gear about a rotational axis of the drive gear and a second gear engaging the set of gear teeth of the knife blade to rotate the knife blade about the central axis, the first and second gears of the drive gear being concentric with the drive gear rotational axis.

In another aspect, the present disclosure relates to a gear train supported in a gearbox housing of a power operated rotary knife to rotate an annular rotary knife blade about a central axis, the gear train comprising: a pinion gear and drive gear wherein the pinion gear engages and rotates the drive gear and the drive gear is configured to engage and rotate an annular rotary knife blade; and wherein the drive gear comprises a double gear including a first gear engaging and being rotated by the pinion gear about a rotational axis of the drive gear and a second gear configured to engage an annular rotary knife blade, the first and second gears of the drive gear being concentric with the drive gear rotational axis.

In another aspect, the present disclosure relates to an annular blade housing for a power operated rotary knife, the blade housing comprising: an inner wall and an outer wall, the inner wall defining a blade housing bearing surface, the blade housing further including a cleaning port having an entry opening and exit opening, the exit opening being in the inner wall and in fluid communication with the blade housing bearing surface.

In another aspect, the present disclosure relates to a power operated rotary knife comprising: an annular rotary knife blade including a wall defining a knife blade bearing surface; an annular blade housing comprising an inner wall and an outer wall, the inner wall defining a blade housing bearing surface on the inner wall; a blade-blade housing bearing structure disposed between the knife blade bearing surface and the blade housing bearing surface, the blade-blade housing bearing structure supporting the knife blade for rotation with respect to the blade housing about a knife blade central axis; and the blade housing further including a cleaning port extending radially between the inner wall and the outer wall, cleaning port including an entry opening and an exit opening, the exit opening being in the inner wall and in fluid communication with the blade housing bearing surface.

In another aspect, the present disclosure relates to an annular blade housing for a power operated rotary knife, the blade housing comprising: an inner wall and an outer wall, the inner wall defining a blade housing bearing surface, the blade housing further including a blade housing plug opening extending between and through the inner wall and the outer wall, an end of the blade housing plug opening at the inner wall intersecting the blade housing bearing surface to provide access to the blade housing bearing surface through the blade housing plug opening, and a blade housing plug configured to be releasably secured within the blade housing plug opening.

In another aspect, the present disclosure relates to a power operated rotary knife comprising: an annular rotary knife blade including a wall defining a knife blade bearing surface; an annular blade housing comprising an inner wall and an outer wall, the inner wall defining a blade housing bearing surface; a blade-blade housing bearing structure disposed between the knife blade bearing surface and the blade housing beating surface, the blade-blade housing bearing structure supporting the knife blade for rotation with respect to the blade housing about a knife blade central axis; and wherein the blade housing further includes a blade housing plug opening extending between and through the inner wall and the outer wall, an end of the blade housing plug opening at the inner wall intersecting the blade housing bearing surface to provide access to the blade housing bearing surface through the blade housing plug opening, and a blade housing plug configured to be releasably secured within the blade housing plug opening.

In another aspect, the present disclosure relates to an annular blade housing comprising: an inner wall and an outer wall, a section of the inner wall defining a blade housing bearing surface, the blade housing bearing surface being axially spaced from opposite first and second ends of the inner wall, the blade housing further including a projection at one of the first and second ends of the inner wall, the projection extending radially inwardly with respect to the section of the inner wall defining the blade housing bearing surface.

In another aspect, the present disclosure relates to a power operated rotary knife comprising: an annular rotary knife blade including a wall defining a knife blade bearing surface; an annular blade housing comprising an inner wall and an outer wall, the inner wall defining a blade housing bearing surface; a blade-blade housing bearing structure disposed between the knife blade bearing surface and the blade housing bearing surface, the blade-blade housing beating structure supporting the knife blade for rotation with respect to the blade housing about a knife blade central axis; and wherein the blade housing further includes a projection at one of the first and second ends of the inner wall, the projection extending radially inwardly with respect to the section of the inner wall defining the blade housing bearing surface.

In another aspect, the present disclosure relates to an annular rotary knife blade for rotation about an axis of rotation in a power operated rotary knife, the rotary knife blade comprising: an annular carrier portion including a first end and an axially spaced apart second end, an outer wall and a radially inward spaced apart inner wall extending respectively between the first end and the second end, the carrier portion including a set of gear teeth and a knife blade bearing surface; an annular blade portion including a first end and an axially spaced apart second end, an outer wall and a radially inward spaced apart inner wall extending respectively between the first end and the second end, and a cutting edge at the blade portion second end, the blade portion configured to be received in a nested relationship by the carrier portion; and an attachment structure for releasably securing the blade portion to the carrier portion, the attachment structure including a plurality of projections extending from one of the outer wall of the blade portion and the inner wall of the carrier portion and a plurality of sockets disposed in the other of the outer wall of the blade portion and the inner wall of the carrier portion, each of the plurality of projections being received in a respective different one of the plurality of sockets to releasably secure the blade portion to the carrier portion.

In another aspect, the present disclosure relates to a power operated rotary knife comprising: a two-part annular rotary knife blade rotating about an axis of rotation and defining a knife blade bearing race, the knife blade including an annular carrier portion, an annular blade portion and an attachment structure; a blade housing including an inner wall defining a blade housing bearing surface; and a blade-blade housing bearing structure disposed between the knife blade bearing surface and the blade housing bearing surface; the knife blade carrier portion including a first end and an axially spaced apart second end, an outer wall and a radially inward spaced apart inner wall extending respectively between the first end and the second end, and a set of gear teeth; the knife blade blade portion including a first end and an axially spaced apart second end, an outer wall and a radially inward spaced apart inner wall extending respectively between the first end and the second end, and a cutting edge at the blade portion second end, the blade portion configured to be received in a nested relationship by the carrier portion; and the knife blade attachment structure for releasably securing the blade portion to the carrier portion, the attachment structure including a plurality of projections extending from one of the outer wall of the blade portion and the inner wall of the carrier portion and a plurality of sockets disposed in the other of the outer wall of the blade portion and the inner wall of the carrier portion, each of the plurality of projections being received in a respective different one of the plurality of sockets to releasably secure the blade portion to the carrier portion.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and advantages of the present disclosure will become apparent to one skilled in the art to which the present disclosure relates upon consideration of the following description of the disclosure with reference to the accompanying drawings, wherein like reference numerals, unless otherwise described refer to like parts throughout the drawings and in which:

FIG. **1** is a schematic front perspective view of a first exemplary embodiment of a power operated rotary knife of the present disclosure including a head assembly, a handle assembly and a drive mechanism, the head assembly including a gearbox assembly, an annular rotary knife blade, a blade housing, and a blade-blade housing support or bearing structure and the handle assembly including a hand piece and a hand piece retaining assembly;

FIG. **2** is a schematic exploded perspective view of the power operated rotary knife of FIG. **1**;

FIG. **2**A is a schematic exploded perspective view of a portion of the head assembly of the power operated rotary knife of FIG. **1** including the rotary knife blade, the blade housing and the blade-blade housing bearing structure that, in one exemplary embodiment, includes an elongated rolling bearing strip that secures and rotatably supports the rotary knife blade with respect to the blade housing;

FIG. **2**B is a schematic exploded perspective view of the handle assembly of the power operated rotary knife of FIG. **1** including the hand piece, the hand piece retaining assembly and a drive shaft latching assembly supported by the hand piece retaining assembly;

FIG. **2**C is a schematic exploded perspective view of a portion of the head assembly of the power operated rotary knife of FIG. **1** including the gearbox assembly, a steeling assembly and a frame body, the gearbox assembly including a gearbox and a gearbox housing;

FIG. **3** is a schematic top plan view of the power operated rotary knife of FIG. **1**;

FIG. **4** is a schematic bottom plan view of the power operated rotary knife of FIG. **1**;

FIG. **5** is a schematic front elevation view of the power operated rotary knife of FIG. **1**;

FIG. **6** is a schematic rear elevation view of the power operated rotary knife of FIG. **1**;

FIG. **7** is a schematic right side elevation view of the power operated rotary knife of FIG. **1**, as viewed from a front or rotary knife blade end of the power operated knife;

FIG. **8** is a schematic section view taken along a longitudinal axis of the handle assembly of the power operated rotary knife of FIG. **1**, as seen from a plane indicated by the line **8-8** in FIG. **3**;

FIG. **8**A is a schematic enlarged section view of a portion of the handle assembly shown in FIG. **8** that is within a dashed circle labeled FIG. **8**A in FIG. **8**;

FIG. **9** is a schematic perspective section view along the longitudinal axis of the handle assembly of the power operated rotary knife of FIG. **1**, as seen from a plane indicated by the line **8-8** in FIG. **3**:

FIG. **10** is a schematic top plan view of an assembled combination of the rotary knife blade, the blade housing, and the blade-blade housing bearing structure of the power operated rotary knife of FIG. **1**;

FIG. **11** is a schematic rear elevation view of the assembled combination of the rotary knife blade, blade housing, and blade-blade housing bearing structure of FIG. **10**, as seen from a plane indicated by the line **11-11** in FIG. **10**, with a blade housing plug removed from the blade housing;

FIG. **12** is a schematic side elevation view of the assembled combination of the rotary knife blade, blade housing, and blade-blade housing bearing structure of FIG. **10**, as seen from a plane indicated by the line **12-12** in FIG. **10**, with a blade housing plug removed from the blade housing;

FIG. **13** is a schematic enlarged section view of the assembled combination of the rotary knife blade, the blade housing and the blade-blade housing bearing structure of the power operated rotary knife of FIG. **1** as seen from a plane indicated by the line **13-13** in FIG. **10**;

FIG. **14** is a schematic perspective view of the elongated rolling bearing strip of the blade-blade housing bearing structure of the power operated rotary knife of FIG. **1**;

FIG. **15** is a schematic section view of the rolling bearing strip of FIG. **14** taken transverse to a longitudinal axis of the strip, as seen from a plane indicated by the line **15-15** in FIG. **14**, to show a schematic section view of an elongated separator cage of the rolling bearing strip at a position where no rolling bearing is located;

FIG. **16** is a schematic top plan view of a short portion of the rolling bearing strip of FIG. **14** taken along the longitudinal axis of the strip, as seen from a plane indicated by the line **16-16** in FIG. **14**, to show a schematic top plan view of the elongated separator cage of the rolling bearing strip at a position where a rolling bearing is located;

FIG. **17** is a schematic section view of the short portion of the rolling bearing strip of FIG. **14**, as seen from a plane indicated by the line **17-17** in FIG. **14**, with the rolling bearing removed to show a schematic section view of a pocket of the elongated separator cage;

FIG. **18** is a schematic perspective view representation of a method of releasably securing the rotary knife blade to the blade housing utilizing the blade-blade housing bearing structure in the power operated rotary knife of FIG. **1**, showing alignment of the elongated rolling bearing strip with an annular passageway defined between the rotary knife blade and the blade housing;

FIG. **19** is a schematic section view representation of a method of releasably securing the rotary knife blade to the blade housing utilizing the blade-blade housing bearing structure in the power operated rotary knife of FIG. **1**, showing partial insertion of the elongated rolling bearing strip into the annular passageway between the rotary knife blade and the blade housing;

FIG. **20** is a schematic section view representation of a method of releasably securing the rotary knife blade to the blade housing utilizing the blade-blade housing bearing structure in the power operated rotary knife of FIG. **1**, showing completion of insertion of the elongated rolling bearing strip into the annular passageway between the knife blade and the blade housing;

FIG. **21** is a schematic section view representation of a method of releasably securing the rotary knife blade to the blade housing utilizing the blade-blade housing bearing structure in the power operated rotary knife of FIG. **1**, showing attachment of the blade housing plug to the blade housing after insertion of the elongated rolling bearing strip into the annular passageway between the knife blade and the blade housing;

FIG. **22** is a schematic enlarged top plan view of a portion of the annular rotary knife blade of the power operated rotary knife of FIG. **1**;

FIG. **23** is schematic enlarged bottom plan view of the portion of the annular rotary knife blade of FIG. **22**;

FIG. **24** is a schematic section view of the annular rotary knife blade of FIG. **22**, as seen from a plane indicated by the line **24-24** in FIG. **22**;

FIG. **25** is a schematic top plan view of the blade housing of the power operated rotary knife of FIG. **1**;

FIG. **26** is a schematic bottom plan view of the blade housing of FIG. **25**;

FIG. **27** is a schematic right side elevation view of the blade housing of FIG. **25**;

FIG. **28** is a schematic rear elevation view of the blade housing of FIG. **25** showing a blade housing plug opening of a mounting section of the blade housing;

FIG. **29** is a schematic section view of the blade housing of FIG. **25** as seen from a plane indicated by the line **29-29** in FIG. **25**;

FIG. **29**A is a schematic enlarged section view of a portion of the blade housing of FIG. **25** that is within a dashed circle labeled FIG. **29**A in FIG. **29**;

FIG. **30** is a schematic top plan view of the blade housing plug that is removably secured to the blade housing of FIG. **25**;

FIG. **31** is a schematic front elevation view of the blade housing plug of FIG. **30** as seen from a plane indicated by the line **31-31** in FIG. **30**;

FIG. **32** is a schematic left side elevation view of the blade housing plug of FIG. **30** as seen from a plane indicated by the line **32-32** in FIG. **30**;

FIG. **33** is a schematic front prospective view of the gearbox assembly of the power operated rotary knife of FIG. **1**;

FIG. **34** is a schematic top plan view of the gearbox assembly of FIG. **33**;

FIG. **35** is a schematic bottom plan view of the gearbox assembly of FIG. **33**;

FIG. **36** is a schematic front elevation view of the gearbox assembly of FIG. **33**;

FIG. **37** is a schematic rear elevation view of the gearbox assembly of FIG. **33**;

FIG. **38** is a schematic right side elevation view of the gearbox assembly of FIG. **33**;

FIG. **39** is a schematic longitudinal section view of the gearbox assembly of FIG. **33**, as seen from a plane indicated by the line **39-39** in FIG. **36**;

FIG. **40** is a schematic longitudinal perspective section view of the gearbox assembly of FIG. **33**, as seen from a plane indicated by the line **39-39** in FIG. **36**;

FIG. **41** is a schematic exploded perspective view of the gearbox assembly of FIG. **33**;

FIG. **42** is a schematic exploded side elevation view of the gearbox assembly of FIG. **33**;

FIG. **43** is a schematic exploded front elevation view of the gearbox assembly of FIG. **33**;

FIG. **44** is a schematic exploded top plan view of the gearbox assembly of FIG. **33**;

FIG. **45** is a schematic exploded rear perspective view of the head assembly of the power operated rotary knife of FIG. **1** showing the gearbox assembly, the frame body, and the assembled combination of the blade, blade housing and blade-blade housing bearing structure;

FIG. **46** is a schematic rear elevation view of the gearbox housing of the gearbox assembly of the power operated rotary knife of FIG. **1**;

FIG. **47** is a schematic front, bottom perspective view of the gearbox housing of FIG. **46**;

FIG. **48** is a schematic longitudinal section view of the gearbox housing of FIG. **46**, as seen from a plane indicated by the line **48-48** in FIG. **46**;

FIG. **49** is a schematic rear perspective view of the frame body of the head assembly of the power operated rotary knife of FIG. **1**;

FIG. **50** is a schematic rear elevation view of the frame body of FIG. **49**;

FIG. **51** is a schematic bottom plan view of the frame body of FIG. **49**;

FIG. **52** is a schematic front elevation view of the frame body of FIG. **49**;

FIG. **53** is a schematic exploded side elevation view of the drive mechanism of the power operated rotary knife of FIG. **1** extending from a drive motor external to the power operated rotary knife to the rotary knife blade of the power operated rotary knife;

FIG. **54** is a schematic view, partly in side elevation and partly in section, depicting use of the power operated rotary knife of FIG. **1** for trimming a layer of material from a product utilizing the "flat blade" style rotary knife blade, shown, for example, in FIG. **24**;

FIG. **55** is a schematic enlarged view, partly in side elevation and partly in section, depicting use of the power operated rotary knife of FIG. **1** for trimming a layer of material from a product utilizing the "flat blade" style rotary knife blade;

FIG. **56** is a schematic section view of a "hook blade" style rotary knife blade and associated blade housing adapted to be used in the power operated rotary knife of FIG. **1**;

FIG. **57** is a schematic section view of a "straight blade" style rotary knife blade and associated blade housing adapted to be used in the power operated rotary knife of FIG. **1**;

FIG. **58** is a is a schematic flow diagram for a method of securing and rotationally supporting the rotary knife blade with respect to the blade housing utilizing the blade-blade housing bearing structure of the power operated rotary knife of FIG. **1**;

FIG. **59** is a schematic perspective view taken from above of an alternate exemplary embodiment of a two-piece or two-part annular rotary knife blade of the present disclosure suitable for use in the power operated rotary knife of FIG. **1**, the rotary knife blade including a carrier portion and a blade portion of the two-piece knife blade in a locked position or an assembled condition;

FIG. **60** is a schematic perspective view taken from below of the rotary knife blade of FIG. **59**;

FIG. **61** is a schematic front elevation view of the rotary knife blade of FIG. **59**;

FIG. **62** is a schematic top plan view of the rotary knife blade of FIG. **59**;

FIG. **63** is a schematic section view of the rotary knife blade of FIG. **59** showing a locking engagement of a projection of the blade portion and a socket of the carrier portion;

FIG. **64** is a schematic section view of the rotary knife blade of FIG. **59** in a region of the blade where there is engagement of a projection of the blade portion and into a first, wider opening region of a socket of the carrier portion, the blade portion projection and the carrier portion socket being part of an attachment structure of the knife blade for releasably securing blade portion to the carrier portion, the first, wider opening region defining a projection receiving opening to accept a projection of the blade portion;

FIG. **65** is a schematic section view of the rotary knife blade of FIG. **59** wherein the projection of the blade portion into the socket of the carrier portion has moved from the first, wider opening region of the socket of the carrier portion (as shown in the sectional view of FIG. **64**) to a second, transition or tapering region of the socket, the second, tapering region of the socket transitions between the first, wider opening region and a third, narrower locking region (shown in the section view of FIG. **66**);

FIG. **66** is a schematic section view of the rotary knife blade of FIG. **59** wherein the projection of the blade portion into the socket of the carrier portion has moved from the second, tapering region of the socket of the carrier portion (as shown in the sectional view of FIG. **65**) to a third, narrow locking region of the socket, the third, narrower locking region defining a locking region to lock a projection of the blade portion so that the blade portion and the carrier portion are in the assembled condition or locked position;

FIG. **67** is a schematic top perspective view of the rotary knife blade of FIG. **59** in an unassembled condition with the blade portion aligned below the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **68** is a schematic bottom perspective view of the rotary knife blade of FIG. **59** in an unassembled condition with the blade portion aligned below the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **69** is a schematic front elevation view of the rotary knife blade of FIG. **59** in an unassembled condition with the blade portion aligned below the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **70** is a schematic bottom plan view of the carrier portion of the knife blade of FIG. **59** showing a plurality of sockets of the attachment structure of the knife blade, in one exemplary embodiment, the plurality of sockets being four;

FIG. **71** is a schematic top plan view of the blade portion of the rotary knife blade of FIG. **59** showing a plurality of projections of the attachment structure of the knife blade, in one exemplary embodiment, the plurality of projections being four projections;

FIG. **72** is a schematic bottom plan view of the blade portion of FIG. **68**;

FIG. **73** is a schematic section view of the blade portion of FIG. **71** taken through one of the plurality of projections as seen from a plane indicated by the line **73-73** in FIG. **71**;

FIG. **74** is a schematic perspective view taken from above of a second alternate exemplary embodiment of a two-piece or two-part annular rotary knife blade of the present disclosure suitable for use in the power operated rotary knife of FIG. **1**, the rotary knife blade including a carrier portion and a blade portion of the two-piece knife blade in a locked position or an assembled condition;

FIG. **75** is a schematic perspective view taken from below of the rotary knife blade of FIG. **74**;

FIG. **76** is a schematic section view of the rotary knife blade of FIG. **74** showing a locking engagement of a projection of the blade portion and a socket of the carrier portion;

FIG. **77** is a schematic top perspective view of the rotary knife blade of FIG. **74** in an unassembled condition with the blade portion aligned above the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **78** is a schematic bottom perspective view of the rotary knife blade of FIG. **74** in an unassembled condition with the blade portion aligned above the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **79** is a schematic section view of the rotary knife blade of FIG. **74** in a region of the blade where there is engagement of a projection of the blade portion and into a first, wider opening region of a socket of the carrier portion, the blade portion projection and the carrier portion socket being part of an attachment structure of the knife blade for releasably securing blade portion to the carrier portion, the first, wider opening region defining a projection receiving opening to accept a projection of the blade portion;

FIG. **80** is a schematic section view of the rotary knife blade of FIG. **74** wherein the projection of the blade portion into the socket of the carrier portion has moved from the first, wider opening region of the socket of the carrier portion (as shown in the sectional view of FIG. **79**) to a second, transition or tapering region of the socket, the second, tapering region of the socket transitions between the first, wider opening region and a third, narrower locking region (shown in the section view of FIG. **81**);

FIG. **81** is a schematic section view of the rotary knife blade of FIG. **74** wherein the projection of the blade portion into the socket of the carrier portion has moved from the second, tapering region of the socket of the carrier portion (as shown in the sectional view of FIG. **80**) to a third, narrow locking region of the socket, the third, narrower locking region defining a locking region to lock a projection of the blade portion so that the blade portion and the carrier portion are in the assembled condition or locked position;

FIG. **82** is a schematic perspective view taken from above of a third alternate exemplary embodiment of a two-piece or two-part annular rotary knife blade of the present disclosure suitable for use in the power operated rotary knife of FIG. **1**, the rotary knife blade including a carrier portion and a blade portion of the two-piece knife blade in a locked position or an assembled condition;

FIG. **83** is a schematic perspective view taken from below of the rotary knife blade of FIG. **82**;

FIG. **84** is a schematic section view of the rotary knife blade of FIG. **82**;

FIG. **85** is a schematic section view of the rotary knife blade of FIG. **82** showing a locking engagement of a projection of the carrier portion and a socket of the blade portion;

FIG. **86** is a schematic top perspective view of the rotary knife blade of FIG. **82** in an unassembled condition with the blade portion aligned above the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **87** is a schematic bottom perspective view of the rotary knife blade of FIG. **82** in an unassembled condition with the blade portion aligned above the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **88** is a schematic section view of the rotary knife blade of FIG. **82** in a region of the blade where there is engagement of a projection of the carrier portion and into a first, wider opening region of a socket of the blade portion, the socket of the blade portion extending through a central wall of the blade portion from an inner wall through an outer wall of the blade portion, the carrier portion projection and the blade portion socket being part of an attachment structure of the knife blade for releasably securing blade portion to the carrier portion, the first, wider opening region defining a projection receiving opening to accept a projection of the carrier portion;

FIG. **89** is a schematic section view of the rotary knife blade of FIG. **82** wherein the projection of the carrier portion into the socket of the blade portion has moved from the first, wider opening region of the socket of the blade portion (as shown in the sectional view of FIG. **88**) to a second, transition or tapering region of the socket, the second, tapering region of the socket transitions between the first, wider opening region and a third, narrower locking region (shown in the section view of FIG. **90**);

FIG. **90** is a schematic section view of the rotary knife blade of FIG. **82** wherein the projection of the carrier portion into the socket of the carrier portion has moved from the second, tapering region of the socket of the carrier portion (as shown in the sectional view of FIG. **89**) to a third, narrow locking region of the socket, the third, narrower locking region defining a locking region to lock a projection of the blade portion so that the blade portion and the carrier portion are in the assembled condition or locked position;

FIG. **91** is a schematic perspective view taken from above of a fourth alternate exemplary embodiment of a two-piece annular rotary knife blade of the present disclosure suitable for use in the power operated rotary knife of FIG. **1**, the rotary knife blade including a carrier portion and a blade portion of the two-piece knife blade in a locked position or an assembled condition;

FIG. **92** is a schematic perspective view taken from below of the rotary knife blade of FIG. **91**;

FIG. **93** is a schematic section view of the rotary knife blade of FIG. **91** showing a locking engagement of a projection of the blade portion and a socket of the carrier portion

FIG. **94** is a schematic top perspective view of the rotary knife blade of FIG. **91** in an unassembled condition with the blade portion aligned above the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **95** is a schematic bottom perspective view of the rotary knife blade of FIG. **91** in an unassembled condition with the blade portion aligned above the carrier portion to schematically illustrate how the blade portion would be received into or would nest with respect to the carrier portion when assembled;

FIG. **96** is a schematic section view of the rotary knife blade of FIG. **91** in a region of the blade where there is engagement of a projection of the blade portion and into a first, wider opening region of a socket of the carrier portion, the blade portion projection and the carrier portion socket being part of an attachment structure of the knife blade for releasably securing blade portion to the carrier portion, the first, wider opening region defining a projection receiving opening to accept a projection of the blade portion;

FIG. **97** is a schematic section view of the rotary knife blade of FIG. **91** wherein the projection of the blade portion into the socket of the carrier portion has moved from the first, wider opening region of the socket of the carrier portion (as shown in the sectional view of FIG. **96**) to a second, transition or tapering region of the socket, the second, tapering region of the socket transitions between the first, wider opening region and a third, narrower locking region (shown in the section view of FIG. **98**);

FIG. **98** is a schematic section view of the rotary knife blade of FIG. **91** wherein the projection of the blade portion into the socket of the carrier portion has moved from the second, tapering region of the socket of the carrier portion (as shown in the sectional view of FIG. **97**) to a third, narrow locking region of the socket, the third, narrower locking region defining a locking region to lock a projection of the blade portion so that the blade portion and the carrier portion are in the assembled condition or locked position; and

FIG. **99** is a schematic section view of the rotary knife blade of FIG. **91** in assembled condition as installed in a corresponding properly configured blade housing of a power operated rotary knife of the present disclosure.

DETAILED DESCRIPTION

First Exemplary Embodiment

Power Operated Rotary Knife **100** Overview

Designers of power operated rotary knives are constantly challenged to improve the design of such knives with respect to multiple objectives. For example, there is a desire for increasing the rotational speed of the rotary knife blade of a power operated rotary knife. Generally, increasing blade rotational speed reduces operator effort required for cutting and trimming operations. There is also a desire for reducing the heat generated during operation of the power operated rotary knife. One source of generated heat is the blade-blade housing bearing interface, that is, heat generated at the bearing interface between the rotating knife blade and the stationary blade housing. Reducing generated heat during power operated rotary knife operation will tend to increase the useful life of various knife components. Additionally, reducing generated heat during knife operation will tend to reduce undesirable "cooking" of the product being cut or trimmed. If sufficient heat is generated in the bearing region of the rotary knife blade and blade housing, dislodged pieces or fragments of a product being cut or trimmed (e.g., small pieces or fragments of fat, gristle or meat dislodged during a trimming or cutting operations) in proximity to the bearing region may become so hot that the pieces “cook”. The cooked materials tend to gum up the blade and blade housing bearing region resulting in even more undesirable heating.

There is further a desire for reducing the vibration of a power operated rotary knife during operation for purposes of improved operator ergonomics and, consequently, improved operator productivity. There is also a desire for increasing the useful life of components of a power operated rotary knife. Areas of potential improvement include the design of the rotary knife blade, the blade housing, the blade-blade housing bearing interface or bearing structure that supports the knife blade for rotation in the blade housing, and the gearing that rotatably drives the rotary knife blade in the blade housing.

Many conventional power operated rotary knives include a so-called split ring, annular blade housing. A split ring or split annular blade housing is one that includes a split through a diameter of the blade housing. The split allows for expansion of a circumference of the blade housing for purposes of removing a rotary knife blade that needs to be sharpened or is at the end of its useful life and inserting a new rotary knife blade. A split ring blade housing has several inherent disadvantages. Because of the split, a split ring blade housing is weaker than a blade housing without a split. Further, the split, which defines a discontinuity along the rotational path of the knife blade, is often a collection point for fragments of meat, fat, gristle and/or bones that are created during a cutting or trimming operation. Accumulation of such fragment or debris in the region of the split may generate heat and/or potentially result in increased vibration of the power operated rotary knife, both of which are undesirable results.

Additionally, a split ring blade housing requires operator adjustment of the blade housing circumference as the rotary knife blade wears. Given the large loading forces applied to the blade when cutting and trimming meat, wear will occur between the bearing structure of the blade and the corresponding bearing structure of the blade housing that support the blade for rotation within the blade housing. In some power operated rotary knives, the blade-blade housing bearing structure includes a portion of a radial outer surface of the rotary knife blade which serves as a bearing structure of the blade and a portion of a radial inner surface of the blade housing which serves as the corresponding or mating bearing structure of the blade housing. In such power operated rotary knifes, the outer radial surface of the blade and the corresponding radial inner surface of the blade housing will wear over time resulting in a gradual loosening of the rotary knife blade within the blade housing.

In certain power operated rotary knives, the blade-blade housing bearing structure comprises an inwardly extending bead of the blade housing that extends into a bearing race formed in a radial outer surface of the rotary knife blade to support the blade for rotation in the blade housing. Again, the bearing race of the blade and the bearing bead of the blade housing will wear over time resulting in looseness of the rotary knife blade within the blade housing. As the rotary knife blade becomes looser within the blade housing, the power operated rotary knife will typically experience increased vibration. An inexperienced operator may simply accept the increased vibration of the power operated rotary knife as a necessary part of using such a knife and will reduce his or her productivity by cutting or trimming at a slower pace, turning the knife off, taking additional time between cuts, etc.

An experienced operator may recognize that a potential solution to the problem of increased vibration is to adjust, that is, reduce the blade housing circumference, i.e., reduce the effective blade housing diameter, to account for the blade and blade housing bearing interface wear. Such an adjustment of the blade housing circumference is a trial and error technique that requires the operator to find a suitable operating clearance. Operating clearance can be viewed as striking a proper balance between providing sufficient blade-blade housing bearing clearance, that is, having the bearing diameter of the blade housing sufficiently larger than the corresponding mating bearing diameter of the knife blade such that the knife blade freely rotates in the blade housing while at the same time not having too much clearance that would cause the knife blade to have excessive play and/or vibrate in the blade housing.

However, even for an experience operator, adjustment of the blade housing circumference may be problematic. If the operator fails to appropriately adjust the blade housing circumference, i.e., find a suitable operating clearance, the power operated rotary knife may not function properly. If the operator's adjustment leads to insufficient operating clearance, the knife blade will not rotate freely in the blade housing, that is, the knife blade will tend to bind in the blade housing thereby generating heat and tending to increase the wear of the rotary knife blade, blade housing and drive gear components, all undesirable results. Depending on the degree of binding, the rotary knife blade may lock-up within the housing. On the other hand if the operator adjusts the blade housing circumference such that the operating clearance is too large, the knife blade will be loose in the blade housing. This may result in excessive movement of the knife blade within the blade housing and attendant problems of excessive vibration of the power operated rotary knife during operation.

Further, even if the operator is successful in adjusting the blade housing to an acceptable circumference, adjustment of the blade housing circumference necessarily requires the operator to cease cutting/trimming operations with the power operated rotary knife during the trial and error adjustment process. The adjustment process results in downtime and lost operator productivity. Finally, since wear of the rotary knife blade and blade housing bearing interface is ongoing as the power operated rotary knife continues to be used for cutting and trimming operations, the blade housing circumference adjustment undertaken by the operator is only a temporary fix as further wear occurs.

The present disclosure relates to a power operated rotary knife that addresses many of the problems associated with conventional power operated rotary knives and objectives of power operated rotary knife design. One exemplary embodiment of a power operated rotary knife of the present disclosure is schematically shown generally at **100** in FIGS. **1-9**. The power operated rotary knife **100** comprises an elongated handle assembly **110** and a head assembly or head portion **111** removably coupled to a forward end of the handle assembly **110**. The handle assembly **110** includes a hand piece **200** that is secured to the head assembly **111** by a hand piece retaining assembly **250**.

In one exemplary embodiment, the head assembly **111** includes a continuous, generally ring-shaped or annular rotary knife blade **300**, a continuous, generally ring-shaped or annular blade housing **400**, and a blade-blade housing support or bearing structure **500**. Annular, as used herein, means generally ring-like or generally ring-shaped in configuration. Continuous annular, as used herein, means a ring-like or ring-shape configuration that is continuous about the ring or annulus, that is, the ring or annulus does not include a split extending through a diameter of the ring or annulus. The head assembly **111** further includes a gearbox assembly **112** and a frame or frame body **150** for securing the rotary knife blade **300** and the blade housing **400** to the gearbox assembly **112**.

The rotary knife blade **300** rotates in the blade housing **400** about a central axis of rotation R. In one exemplary embodiment, the rotary knife blade **300** includes a bearing surface **319** and a driven gear **328**. Both the bearing race **319** and the driven gear **328** are axially spaced from an upper end **306** of a body **302** of the blade **300** and from each other. The rotary knife blade **300** is supported for rotation in the blade housing **400** by the blade-blade housing support or bearing structure **500** of the present disclosure (best seen in FIGS. **2**A and **14**). The blade-blade housing bearing structure **500** advantageously both supports the rotary knife blade **300** for rotation with respect to the blade housing **400** and releasably secures the rotary knife blade **300** to the blade housing **400**.

In one exemplary embodiment, the blade-blade housing bearing structure **500** includes an elongated rolling bearing strip **502** (FIG. **14**) having a plurality of spaced apart rolling bearings **506** supported in a flexible separator cage **508**. The elongated rolling bearing strip **502** is disposed in an annular passageway **504** (FIG. **13**) formed between opposing bearing surfaces **319**, **459** of the rotary knife blade **300** and the blade housing **400**, respectfully. The blade-blade housing bearing structure **500** defines a plane of rotation RP (FIGS. **7** and **8**) of the rotary knife blade **300** with respect to the blade housing **400**, the rotational plane RP being substantially orthogonal to the rotary knife blade central axis of rotation R.

In one exemplary embodiment, the plurality of rolling bearings **506** comprises a plurality of generally spherical ball bearings. The plurality of ball or rolling bearings **506** are in rolling contact with and bear against the opposing bearing surfaces **319**, **459** of the rotary knife blade **300** and the blade housing **400** to support the knife blade **300** for rotation with respect to the blade housing **400** and secure the knife blade **300** with respect to the blade housing **400**. The flexible separator cage **508** rotatably supports and locates the plurality of rolling bearings **506** in spaced apart relation within the annular passageway **504**. The flexible separator cage **508** does not function as a bearing structure or provide a bearing surface with respect to the rotary knife blade **300** and the blade housing **400**. The function of rotatably supporting the rotary knife blade **300** with respect to the blade housing **400** is solely provided by the rolling bearing support of the plurality of spaced apart ball bearings **506**. This rolling bearing support can be contrasted with power operated rotary knives utilizing a sliding bearing structure. For example, U.S. Pat. No. 6,769,184 to Whited, discloses a sliding bearing structure comprising a blade housing having a plurality of circumferentially spaced, radially inwardly extending bead sections that extend into and bear against a bearing race or groove of a rotary knife blade and U.S. Published Application Pub. No. US 2007/0283573 to Levsen, which discloses a sliding bearing structure comprising an annular bushing having an elongated bushing body disposed along a groove in a blade housing and in contact with opposing bearing surfaces of a rotary knife blade and the blade housing.

As can best be seen in the sectional view of FIG. **13**, the flexible separator cage **508** is configured to ride in the annular passageway **504** without substantial contact with either the knife blade **300** or the blade housing **400** or the opposing bearing surfaces **319**, **459** of the knife blade **300** and blade housing. Indeed, it would not be desired for the flexible separator cage **508** to be in contact with or in bearing engagement with either the rotary knife blade **300** or the blade housing **400** as this would resulting in undesirable sliding friction. The blade-blade housing bearing structure **500** rotatably supports the knife blade **300** with respect to the blade housing **400** via rolling bearing support provided by the plurality of ball bearings **506** of the rolling bearing strip **502** bearing against the opposing bearing surfaces **319**, **459** of the rotary knife blade **300** and the blade housing **400**.

The rotational speed of a specific rotary knife blade **300** in the power operated rotary knife **100** will depend upon the specific characteristics of a drive mechanism **600** (shown schematically in FIG. **53**) of the power operated rotary knife **100**, including an external drive motor **800**, a flexible shaft drive assembly **700**, a gear train **604**, and a diameter and gearing of the rotary knife blade **300**. Further, depending on the cutting or trimming task to be performed, different sizes and styles of rotary knife blades may be utilized in the power operated rotary knife **100** of the present disclosure. For example, rotary knife blades in various diameters are typically offered ranging in size from around 1.4 inches in diameter to over 7 inches in diameter. Selection of a blade diameter will depend on the task or tasks being performed.

Increasing the rotational speed of the rotary knife blade of a power operated rotary knife is an important objective of designers of power operated rotary knives. The rolling bearing structure of the blade-blade housing bearing structure **500** of the present disclosure results in reduced friction, less generated heat and less surface wear than would be the case with a sliding or journal bearing structure. Because of the reduced friction and heat resulting from a rolling bearing structure, the rolling blade-blade housing bearing structure **500** permits increased rotational speed of the rotary knife blade **300** compared to the sliding bearing structures disclosed or used in prior power operated rotary knives.

By way of example only and without limitation, the following table compares blade rotational speed of two exemplary power operated rotary knives of the present disclosure versus the assignee's previous versions of those same models of power operated rotary knives. Of course, it should be appreciated the blade rotational speed increase will vary by model and will be dependent upon the specific characteristics of each particular model and blade size.

Model	Approx. Blade Diameter	Approximate Blade Rotational Speed % Increase
1000/1500	5.0 inches	51% (930 RPM vs. 1,400 RPM)
620	2.0 inches	57% (1,400 RPM vs. 2,200 RPM)

There are also significant advantages to using the flexible separator cage **508** to support and locate the plurality of rolling bearings **506**, as opposed to, for example, using only a plurality of rolling bearings, such as ball bearings, inserted into a gap or passageway between the rotary knife blade and the blade housing. The flexible separator cage **508** facilitates insertion of and removal of, as a group, the plurality of rolling bearings **506** into and from the annular passageway **504**. That is, it is much easier to insert the rolling bearing strip **502** into the annular passageway **504**, as opposed to attempting to insert individual rolling bearings into the annular passageway **504** in a one-at-a-time, sequential order, which would be both time consuming and fraught with difficulty. This is especially true in a meat processing environment where a dropped or misplaced rolling bearing could fall into a cut or trimmed meat product. Similarly, removal of the plurality of rolling bearings **506**, as a group, via removal of the rolling bearing strip **502** is much easier and less prone to dropping or losing rolling bearings than individually removing rolling bearings from the annular passageway **504**.

Additionally, from the viewpoints of friction, bearing support and cost, utilizing the plurality of rolling bearings **506** supported in a predetermined, spaced apart relationship by the flexible separator cage **508**, is more efficient and effective than utilizing a plurality of rolling bearings disposed loosely in a gap or passageway between the rotary knife blade and the blade housing. For example, the separator cage **508** allows for the plurality of rolling bearings **506** to be appropriately spaced to provide sufficient rolling bearing support to the rotary knife blade **300** given the application and characteristics of the product or material to be cut or trimmed with the power operated rotary knife **100**, while at the same time, avoids the necessity of having more rolling bearings than required for proper bearing support of the rotary knife blade **500** and the application being performed with the power operated rotary knife **100**.

For example, if the individual rolling bearings are tightly packed in a one-adjacent-the-next relationship in the annular passageway **504**, more rolling bearings than needed for most applications would be provided, thereby unnecessarily increasing cost. Further, having more rolling bearings than needed would also increase total friction because of the friction between each pair of adjacent, in-contact, rolling bearings. If, on the other hand, the individual rolling bearings are loosely packed in the annular passageway **504**, there is no control over the spacing between adjacent rolling bearings. Thus, there may be instances where a large gap or space may occur between two adjacent rolling bearings resulting in insufficient bearing support in a particular region of the annular passageway **504**, given the cutting forces being applied to the rotary knife blade **300** during a specific cutting or trimming application or operation.

As can best be seen in FIG. **2**, an assembled combination **550** of the rotary knife blade **300**, the blade housing **400** and blade-blade housing bearing structure **500** is releasably secured as a unitary structure to the gearbox assembly **112** by the frame body **150** thereby completing the head assembly **111**. For brevity, the assembled combination **550** of the rotary knife blade **300**, the blade housing **400** and blade-blade housing bearing structure **500** will hereinafter be referred to as the blade-blade housing combination **550**. The handle assembly **110** is releasably secured to the head assembly **111** thereby completing the power operated rotary knife **100**. As used herein, a front or distal end of the power operated rotary knife **100** is an end of the knife **100** that includes the blade-blade housing combination **550** (as seen in FIG. **1**), while a rear or proximal end of the power operated rotary knife **100** is an end of the knife **100** that includes the handle assembly **110**, and specifically, an enlarged end **260** of an elongated central core **252** of the hand piece retaining assembly **250** (as seen in FIG. **1**).

The head assembly **111** includes the frame **150** and the gearbox assembly **112**. As is best seen in FIGS. **2**C and **33**, the gearbox assembly **112** includes a gearbox housing **113** and a gearbox **602**. The gearbox **602** is supported by the gearbox housing **113**. The gearbox **602** includes the gear train **604** (FIG. **41**). The gear train **604** includes, in one exemplary embodiment, a pinion gear **610** and a drive gear **650**. The gearbox **602** includes the gear train **604**, along with a bearing support assembly **630** that rotatably supports the pinion gear **610** and a bearing support assembly **660** that rotatably supports the drive gear **650**.

The drive gear **650** is a double gear that includes a first bevel gear **652** and a second spur gear **654**, disposed in a stacked relationship, about an axis of rotation DGR (FIG. **8**A) of the drive gear **650**. The drive gear axis of rotation DRG is substantially parallel to the rotary knife blade axis of rotation R. The drive gear first bevel gear **652** meshes with the pinion gear **610** to rotatably drive the drive gear **650** about the drive gear axis of rotation DGR. The second spur gear **654** of the drive gear engages the driven gear **328** of the rotary knife blade **300**, forming an involute gear drive, to rotate the knife blade **300** about the blade axis of rotation R.

The gear train **604** is part of the drive mechanism **600** (shown schematically in FIG. **53**), some of which is external to the power operated rotary knife **100**, that provides motive power to rotate the rotary knife blade **300** with respect to the blade housing **400**. The drive mechanism **600** includes the external drive motor **800** and the flexible shaft drive assembly **700**, which is releasably secured to the handle assembly **110** by a drive shaft latching assembly **275** (FIG. **2**B). The gear train **604** of the power operated rotary knife **100** transmits rotational power from a rotating drive shaft **702** of the flexible shaft drive assembly **700**, through the pinion and drive gears **610**, **650**, to rotate the rotary knife blade **300** with respect to the blade housing **400**.

The frame body **150** (FIGS. **2**C and **49**) of the head assembly **111** includes an arcuate mounting pedestal **152** at a front or forward end of the frame body **150**. The arcuate mounting pedestal **152** defines a seating region **152***a* for a mounting section **402** of the blade housing **400** such that the blade-blade housing combination **550** may be releasably affixed to the frame body **150**. The frame body **150** also defines a cavity or opening **155** (FIG. **49**) that slidably receives the gearbox housing **113**, as the gearbox housing is moved in a forward direction FW (FIGS. **3**, **7** and **45**) along the longitudinal axis LA in the direction of the frame body **150**. When the gearbox housing **113** is fully inserted into the frame cavity **155** and secured to the frame body **150** by a pair of threaded fasteners **192**, as is shown schematically in FIG. **53**, the drive gear **650** of the gear train **604** engages and meshes with the driven gear **328** of the rotary knife blade **300** to rotate the blade **300** about its axis of rotation R.

The frame body **150** releasably couples the blade-blade housing combination **550** to the gearbox housing **113** to form the head assembly **111** of the power operated rotary knife **100**. The hand piece **200** of the handle assembly **110** is secured or mounted to the head assembly **111** by the hand piece retaining assembly **250** (FIG. **2**B) to complete the power operated rotary knife **100**. The elongated central core **252** of the hand piece retaining assembly **250** extends through a central throughbore **202** of the hand piece **200** and threads into the gearbox housing **113** to secure the hand piece **200** to the gearbox housing **113**.

The handle assembly **110** (FIG. **2**B) extends along a longitudinal axis LA (FIGS. **3**, **7** and **8**) that is substantially orthogonal to the central axis of rotation R of the rotary knife blade **300**. The hand piece **200** includes an inner surface **201** that defines the central throughbore **202**, which extends along the handle assembly longitudinal axis LA. The hand piece **200** includes a contoured outer handle or outer gripping surface **204** that is grasped by an operator to appropriately manipulate the power operated rotary knife **100** for trimming and cutting operations.

In one exemplary embodiment, the hand piece **200** and the elongated central core **252** of the handle assembly **110** may be fabricated of plastic or other material or materials known to have comparable properties and may be formed by molding and/or machining. The hand piece **200**, for example, may be fabricated of two over molded plastic layers, an inner layer comprising a hard plastic material and an outer layer or gripping surface comprised of a softer, resilient plastic material that is more pliable and easier to grip for the operator. The gearbox housing **113** and the frame body **150** of the head assembly **111** may be fabricated of aluminum or stainless steel or other material or materials known to have comparable properties and may be formed/shaped by casting and/or machining. The blade and blade housing **400** may be fabricated of a hardenable grade of alloy steel or a hardenable grade of stainless steel, or other material or materials known to have comparable properties and may be formed/shaped by machining, forming, casting, forging, extrusion, metal injection molding, and/or electrical discharge machining or another suitable process or combination of processes.

Rotary Knife Blade **300**

In one exemplary embodiment and as best seen in FIGS. **2**A and **22-24**, the rotary knife blade **300** of the power operated rotary knife **100** is a one-piece, continuous annular structure. As can best be seen in FIG. **24**, the rotary knife blade **300** includes the body **302** and a blade section **304** extending axially from the body **302**. The knife blade body **302** includes an upper end **306** and a lower end **308** spaced axially from the upper end **306**. The body **302** of the rotary knife blade **300** further includes an inner wall **310** and an outer wall **312** spaced radially apart from the inner wall **310**. An upper, substantially vertical portion **340** of the body outer wall **312** defines the knife blade bearing surface **319**. In one exemplary embodiment of the power operated rotary knife **100** and as best seen in FIGS. **13** and **24**, the knife blade bearing surface **319** comprises the bearing race **320** that extends radially inwardly into the outer wall **312**. In one exemplary embodiment, the knife blade bearing race **320** defines a generally concave bearing surface, and, more specifically, a generally arcuate bearing face **322** in a central portion **324** of the bearing race **320**. As can be seen in FIG. **24**, the knife blade bearing race **320** is axially spaced from an upper end **306** of the knife blade body **302**. Specifically, a section **341** of the vertical portion **340** of the body outer wall **312** extends between the knife blade bearing race **320** and the upper end **306** of the knife blade body **302**. Stated another way, the knife blade body outer wall **312** includes the vertical section **341** which separates the knife blade bearing race **320** from the upper end **306** of the knife blade body **302**. When viewed in three dimensions, the vertical section **341** defines a uniform diameter, cylindrical portion of the knife blade body outer wall **312** which separates the knife blade bearing race **320** from the upper end **306** of the knife blade body **302**.

The outer wall **312** of the body **302** of the rotary knife blade **300** also defines the driven gear **328**. The driven gear **328** comprises a set of spur gear teeth **330** extending radially outwardly in a stepped portion **331** of the outer wall **312**. The blade gear **330** is a spur gear which means that it is a cylindrical gear with a set of gear teeth **328** that are parallel to the axis of the gear, i.e., parallel to the axis of rotation R of the rotary knife blade **300** and a profile of each gear tooth of the set of gear teeth **328** includes a tip or radially outer surface **330***a* (FIG. **13**) and a root or radially inner surface **330***b*. The root **3301**, of the gear tooth is sometimes referred to as a bottom land, while the tip **330***a* of the gear tooth is sometimes referred to as a top land. The root **330***b* is radially closer to the axis of rotation R of the blade **300**, the root **330***b* and the tip **330***a* are radially spaced apart by a working depth plus clearance of a gear tooth of the set of gear teeth **330**. The driven gear **328** of the rotary knife blade **300** is axially spaced from and disposed below the bearing race **320**, that is, closer to the second lower end **308** of the knife blade body **302**. The knife blade body outer wall **312** includes the vertical portion **340** which separates the set of gear teeth **330** from the upper end **306** of the knife blade body **302**. When viewed in three dimensions, the vertical portion **340** defines a uniform diameter, cylindrical portion of the knife blade body outer wall **312** which separates the knife blade bearing race **320** from the upper end **306** of the knife blade body **302**. The driven gear **328**, in one exemplary embodiment, defines a plurality of involute spur gear teeth **332**.

The set of spur gear teeth **330** of the knife blade driven gear **328** are axially spaced from both the upper end **306** of the body **302** and the lower end **308** of the body **302** and are axially spaced from the arcuate bearing race **320** of the body **302**. Additionally, the driven gear **328** is also offset radially inwardly with respect to the upper vertical portion **340** of the body outer wall **312** that defines the blade bearing race **320**. Specifically, the set of spur gear teeth **330** are disposed radially inwardly of an outermost extent **343** of the outer wall **312** of the knife blade body **302**. As can be seen in FIGS. **13** and **24**, the upper vertical portion **340** of the body outer wall **312** defines the outermost extent **343** of the outer wall **312**. Accordingly, the upper vertical portion **340** of the outer wall **312** extends radially outwardly over the set of gear teeth **330** and form a gear tooth cap **349**. The gear tooth cap **349** is axially spaced from and overlies the set of gear teeth **330** and functions to further protect the set of gear teeth **330**.

This configuration of the rotary knife blade **300**, wherein the set of gear teeth **330** are both axially spaced from the upper end **306** of the knife blade body **302** and inwardly offset from the outermost extent **343** of the blade body outer wall **312** is sometimes referred to as a "blind gear tooth" configuration. Advantageously, the driven gear **328** of the rotary knife blade **300** of the present disclosure is in a relatively protected position with respect to the knife blade body **302**. That is, the driven gear **328** is in a position on the knife blade body **302** where there is less likely to be damage to the set of gear teeth **330** during handling of the rotary knife blade **300** and, during operation of the power operated rotary knife **100**, there is less ingress of debris, such as small pieces fat, meat, bone and gristle generated during cutting and trimming operations, into the gear teeth region.

Conceptually, the respective gear tips or radially outer surfaces **330***a* of the set of gear teeth **330**, when the knife blade **300** is rotated, can be viewed as forming a first imaginary cylinder **336** (shown schematically in FIG. **24**). Similarly, the respective roots or radially inner surfaces **330***b* of the set of gear teeth **330**, when the knife blade **300** is rotated, can be viewed as forming a second imaginary cylinder **337**. A short radially or horizontally extending portion **342** of the outer wall **312** of the blade body **302** extends between the radially outer surfaces **330***a* of the driven gear **328** and the vertical upper portion **340** of the outer wall **312** of the blade body. A second substantially vertical lower portion **344** of the outer wall **312** of the blade body **302** extends between a bottom surface **345** of the driven gear **328** and the lower end **308** of the blade body. As can be seen in FIG. **24**, the vertical lower portion **344** of the knife blade body **302** results in a radially extending projection **348** adjacent the lower end **308** of the blade body **302**.

Axial spacing of the drive gear **328** from the upper end **306** of the knife blade body **302** advantageously protects the set of gear teeth **330** from damage that they would otherwise be exposed to if, as is the case with conventional rotary knife blades, the set of gear teeth **330** were positioned at the upper end **306** of the blade body **302** of the rotary knife blade **300**. Additionally, debris is generated by the power operated rotary knife **100** during the cutting/trimming operations. Generated debris include pieces or fragments of bone, gristle, meat and/or fat that are dislodged or broken off from the product being cut or trimmed by the power operated rotary knife **100**. Debris may also include foreign material, such as dirt, dust and the like, on or near a cutting region of the product being cut or trimmed. Advantageously, spacing the set of gear teeth **330** from both axial ends **306**, **308** of the knife blade body **302**, impedes or mitigates the migration of such debris into the region of the knife blade driven gear **328**. Debris in the region of knife blade driven gear **328** may cause or contribute to a number of problems including blade vibration, premature wear of the driven gear **328** or the mating drive gear **650**, and "cooking" of the debris.

Similar advantages exist with respect to axially spacing the blade bearing race **320** from the upper and lower ends **306**, **308** of the blade body **302**. As will be explained below, the rotary knife blade body **302** and the blade housing **400** are configured to provide radially extending projections or caps which provide a type of labyrinth seal to inhibit entry of debris into the regions of the knife blade driven gear **328** and the blade-blade housing bearing structure **500**. These labyrinth seal structures are facilitated by the axial spacing of the knife blade drive gear **328** and the blade bearing race **320** from the upper and lower ends **306**, **308** of the blade body **302** of the rotary knife blade **300**.

As can best be seen in FIG. **24**, in the rotary knife blade **300**, the second end **308** of the knife blade body **302** transitions radially inwardly between the body **302** and the blade section **304**. The second end **308** of the body **302** is defined by a radially inwardly extending step or shoulder **308***a*. The blade section **304** extends from the second end **308** of the body **302** and includes a blade cutting edge **350** at an inner, lower end **352** of the blade section **304**. As can be seen, the blade section **304** includes an inner wall **354** and a radially spaced apart outer wall **356**. The inner and outer walls **354**, **356** are substantially parallel. A bridging portion **358** at the forward end of the rotary knife blade **300** extends between the inner and outer walls **354**, **356** and forms the cutting edge **350** at the intersection of the bridging portion **358** and the inner wall **354**. Depending on the specific configuration of the blade section **304**, the bridging portion **358** may extend generally radially or horizontally between the inner and outer walls **354**, **356** or may taper at an angle between the inner and outer walls **354**, **356**.

The rotary knife blade body inner wall **310** and the blade section inner wall **354** together form a substantially continuous knife blade inner wall **360** that extends from the upper end **306** to the cutting edge **350**. As can be seen in FIG. **24**, there is a slightly inwardly protruding "humpback" region **346** of the inner wall **310** of the blade body **302** in the region of the bearing race **320**. The protruding region **346** provides for an increased width or thickness of the blade body **302** in the region where the bearing race **320** extends radially inwardly into the blade body outer wall **312**. The knife blade inner wall **360** is generally frustoconical in shape, converging in a downward direction (labeled DW in FIG. **24**), that is, in a direction proceeding away from the driven gear **328** and toward the cutting edge **350**. The knife blade inner wall **360** defines a cutting opening CO (FIGS. **1** and **54**) of the power operated rotary knife **100**, that is, the opening defined by the rotary knife blade **300** that cut material, such as a cut layer CL1 (FIG. **54**) passes through, as the power operated rotary knife **100** trims or cut a product P.

Blade Housing **400**

In one exemplary embodiment and as best seen in FIGS. **25-29**, the blade housing **400** of the power operated rotary knife **100** is a one-piece, continuous annular structure. The blade housing **400** includes the mounting section **402** and a blade support section **450**. The blade housing **400** is continuous about its perimeter, that is, unlike prior split-ring annular blade housings, the blade housing **400** of the present disclosure has no split along a diameter of the housing to allow for expansion of the blade housing circumference. The blade-blade housing bearing or support structure **500** of the present disclosure secures the rotary knife blade **300** to the blade housing **400**. Accordingly, removal of the knife blade **300** from the blade housing **400** is accomplished by removing a portion of the blade-blade housing structure **500** from the power operated rotary knife **100**. The blade-blade housing bearing structure **500** permits use of the continuous annular blade housing **400** because there is no need to expand the blade housing circumference to remove the rotary knife blade **300** from the blade housing **400**.

The continuous annular blade housing **400** of the present disclosure provides a number of advantages over prior split-ring annular blade housings. The one-piece, continuous annular structure provides for greater strength and durability of the blade housing **400**, as compared to prior split-ring annular blade housings. In addition to greater strength and durability of the blade housing **400**, the fact that a circumference of the blade housing **400** is not adjustable eliminates need for and precludes the operator from adjusting the circumference of the blade housing **400** during operation of the power operated rotary knife **100** in an attempt to maintain proper operating clearance. This is a significant improvement over the prior split ring annular blade housings. Advantageously, the combination of the rotary knife blade **300**, the blade housing **400** and the blade-blade housing bearing structure **500** of the power operated rotary knife **100** provide for proper operating clearance of the rotary knife blade **300** with respect to the blade housing **400** over the useful life of a given rotary knife blade.

As can best be seen in FIG. **25**, in the blade housing **400**, the blade support section extends around the entire 360 degrees (360°) circumference of the blade housing **400**. The mounting section **402** extends radially outwardly from the blade support section **450** and subtends an angle of approximately 120°. Stated another way, the blade housing mounting section **402** extends approximately ⅓ of the way around the circumference of the blade housing **400**. In the region of the mounting section **402**, the mounting section **402** and the blade support section **450** overlap.

The mounting section **402** is both axially thicker and radially wider than the blade support section **450**. The blade housing mounting section **402** includes an inner wall **404** and a radially spaced apart outer wall **406** and a first upper end **408** and an axially spaced apart second lower end **410**. At forward ends **412**, **414** of the mounting section **402**, there are tapered regions **416**, **418** that transition between the upper end **408**, lower end **410** and outer wall **406** of the mounting section and the corresponding upper end, lower end and outer wall of the blade support section **450**.

The blade housing mounting section **402** includes two mounting inserts **420**, **422** (FIG. 2A) that extends between the upper and lower ends **408**, **410** of the mounting section **402**. The mounting inserts **420**, **422** define threaded openings **420***a*, **422***a*. The blade housing mounting section **402** is received in the seating region **152***a* defined by the arcuate mounting pedestal **152** of the frame body **150** and is secured to the frame body **150** by a pair of threaded fasteners **170**, **172** (FIG. 2C). Specifically, the pair of threaded fasteners **170**, **172** extend through threaded openings **160***a*, **162***a* defined in a pair of arcuate arms **160**, **162** of the frame body **150** and thread into the threaded openings **420***a*, **422***a* of the blade housing mounting inserts **420**, **422** to releasably secure the blade housing **400** to the frame body **150** and, thereby, couple the blade housing **400** to the gearbox assembly **112** of the head assembly **111**.

The mounting section **402** further includes a gearing recess **424** (FIGS. **25** and **28**) that extends radially between the inner and outer walls **404**, **406**. The gearing recess **424** includes an upper clearance recess **426** that does not extend all the way to the inner wall and a wider lower opening **428** that extends between and through the inner and outer walls **404**, **406**. The upper clearance recess **426** provides clearance for the pinion gear **610** and the axially oriented first bevel gear **652** of the gearbox drive gear **650**. The lower opening **428** is sized to receive the radially extending second spur gear **654** of the gearbox drive gear **650** and thereby provide for the interface or meshing of the second spur gear **654** and the driven gear **328** of the rotary knife blade **300** to rotate the knife blade **300** with respect to the blade housing **400**.

The mounting section **402** of the blade housing **400** also includes a blade housing plug opening **429** that extends between the inner and outer walls **404**, **406**. The blade housing plug opening **429** is generally oval-shaped in cross section and is sized to receive a blade housing plug **430** (FIGS. **30-32**). The blade housing plug **430** is removably secured to the blade housing **400** by two screws **432** (FIG. **2**A). The screws **432** pass through a pair of countersunk openings **434** that extend from the upper end **408** of the mounting section **402** to the lower portion **428** of the gearing recess **424** and threaded engage a pair of aligned threaded openings **438** of the blade housing plug **430**.

As can best be seen in FIG. **29**A, the blade support section **450** includes an inner wall **452** and radially spaced apart outer wall **454** and a first upper end **456** and an axially spaced second lower end **458**. The blade support section **450** extends about the entire 360° circumference of the blade housing **400**. The blade support section **450** in a region of the mounting section **402** is continuous with and forms a portion of the inner wall **404** of the mounting section **402**. As can be seen in FIG. **29**, a portion **404***a* of the inner wall **404** of the mounting section **402** of the blade housing **400** within the horizontally extending dashed lines IWBS constitutes both a part of the inner wall **404** of the mounting section **402** and a part of the of the inner wall **452** of the blade support section **450**. The dashed lines IWBS substantially correspond to an axial extent of the inner wall **452** of the blade support section **450**, that is, the lines IWBS correspond to the upper end **456** and the lower end **458** of the blade support section **450**. A substantially vertical portion **452***a* of the blade support section inner wall **452** adjacent the first upper end **456** defines the blade housing bearing surface **459**. In one exemplary embodiment of the power operated rotary knife **100** and as best seen in FIGS. **13** and **29**A, the blade housing bearing surface **459** comprises a bearing race **460** that extends radially inwardly into the inner wall **452**. The bearing race **460** is axially spaced from the upper end **456** of the blade support section **450**. In one exemplary embodiment, a central portion **462** of the blade housing bearing race **460** defines a generally concave bearing surface, and, more specifically, a generally arcuate bearing face **464**.

In one exemplary embodiment of the power operated rotary knife **100**, the knife blade bearing surface **319** is concave with respect to the outer wall **312**, that is, the knife blade bearing surface **319** extends into the outer wall **312** forming the bearing race **320**. It should be appreciated that the knife blade bearing surface **319** and/or the blade housing bearing surface **459** may have a different configuration, e.g., in an alternate embodiment, the knife blade bearing surface **319** and the blade housing bearing surface **459** could, for example, be convex with respect to their respective outer and inner walls **312**, **452**. The plurality of rolling bearings **506** of the blade-blade housing bearing structure **500** would, of course, have to be configured appropriately.

Though other geometric shapes could be used, the use of arcuate bearing faces **322**, **464** for the bearing races **320**, **460** of both the rotary knife blade **300** and the blade housing **400** is well suited for use with the power operated knife **100** of the present disclosure. Due to the unpredictable and varying load direction the plurality of ball bearing **506** and the arcuate bearing faces **322**, **464** allow the rotary knife blade **300** and blade housing **400** to be assembled in such a way to allow for running or operating clearance. This helps to maintain to the extent possible, the theoretical ideal of a single point of rolling bearing contact between a given ball bearing of the plurality of ball bearings **506** and the rotary knife blade arcuate bearing face **322** and the theoretical ideal of a single point of rolling bearing contact between a given ball bearing of the plurality of ball bearings **506** and the blade housing bearing face **464**. (It being understood, of course, that a single point of rolling bearing contact is a theoretical because deformation between a ball bearing and a bearing race necessarily causes deformation of the ball bearing and the bearing race resulting in a small region of contact as opposed to a point of contact.) Nevertheless, the arcuate bearing face configurations **322**, **464** provide for reduced frictional torque produced in the bearing region. Due to the thin cross sections of the rotary knife blade **300** and the blade housing **400** of the power operated rotary knife **100**, there is a tendency for both the inner or blade bearing race **320** and the outer or blade housing outer race **460** to flex and bend while in use. An arcuate bearing race design of slightly larger radius than the ball of the plurality of ball bearings **506** will allow the balls to move along an arc defined by the annular passageway **504** and still contact the respective bearing races **320**, **460** at respective single points thereby maintaining low friction even during bending and flexing of the rotary knife blade **300** and the blade housing **400**. The arcuate shape of the blade and blade housing bearing races **320**, **460** also helps compensate for manufacturing irregularities within the rotary knife blade **300** and the blade housing **400** and thereby helps maintain theoretical ideal of the single point of bearing contact between a ball bearing of the plurality of ball bearings **506** and the respective bearing races **320**, **460**, as discussed above, thereby reducing friction.

A radially inner wall **440** (FIGS. **2**A, **30** and **31**) of the blade housing plug **430** defines a bearing race **442** that is a portion of and is continuous with the bearing race **460** of the blade housing **400**. Like the portion **404***a* of the inner wall **404** of the mounting section **402** of the blade housing **400** within the horizontally extending dashed lines IWBS, a portion of the inner wall **440** of the blade housing plug **430** that would be within the horizontally extending dashed lines IWBS of FIG. **29** is both a part of the inner wall **440** of the blade housing plug **430** and a part of the inner wall **452** of the blade support section **450**. Thus, when the blade housing plug **430** is inserted in the blade housing plug opening **429** of the blade housing **400**, the blade housing bearing race **460** is substantially continuous about the entire 360° circumference of the blade support section **450**.

As can best be seen in FIG. **13**, when the blade is secured and supported within the blade housing **400** by the blade-blade housing support structure **500**, in order to impede the ingress of pieces of meat, bone and other debris into the driven gear **328** of the rotary knife blade **300**, a radially outwardly extending driven gear projection or cap **466** at the lower end **458** of the blade support section **450** is axially aligned with and overlies at least a portion of the bottom surface **345** of the set of gear teeth of the knife blade driven gear **328**. The driven gear projection or cap **466** defines the lower end **458** of the blade support section **450**. The driven gear cap **466** overlies or bridges a gap between the first and second imaginary cylinders **336**, **337** (FIG. **24**) formed by the driven gear **328** of the rotary knife blade **300**. As can be seen in FIG. **13**, because of the radial projection **348** of the knife blade body **302** and the driven gear cap **466**, only a small radial clearance gap exists between the radially extending end **467** of the driven gear cap **466** of the blade housing **400** and the projection vertical lower portion **344** of outer wall **312** of the knife blade body **302**. Advantageously, the combination of the knife blade radial projection **348** and the blade housing cap **466** form a type of labyrinth seal that inhibits ingress of debris into the regions of the driven gear **328** and the bearing race **320** of the rotary knife blade **300**.

As can best be seen in FIG. **13**, the blade support section inner wall **452** of the blade housing **400** includes a first radially outwardly extending ledge **470** that is located axially below the blade housing bearing race **460**. The blade support section inner wall **452** also includes a second radially outwardly extending ledge **472** that forms an upper surface of the driven gear cap portion **466** and is axially spaced below the first radially outwardly extending ledge **470**. The first and second ledges **470**, **472** provide a seating regions for the horizontally extending portion **342** of the knife blade outer wall **312** and the bottom surface **345** of the set of gear teeth **330**, respectively, to support the knife blade **300** when the knife blade **300** is positioned in the blade housing **400** from axially above and the rolling bearing strip **502** of the blade-blade housing bearing structure **500** has not been inserted into a passageway **504** (FIG. **13**) between the rotary knife blade **300** and the blade housing **400** defined by opposing arcuate bearing faces **322**, **464** of the knife blade bearing race **320** and the blade housing bearing race **460**. Of course, it should be understood that without insertion of the rolling bearing strip **502** into the passageway **504**, if the power operated rotary knife **100** were turned upside down, that is, upside down from the orientation of the power operated rotary knife **100** shown, for example, in FIG. **7**, the rotary knife blade **300** would fall out of the blade housing **400**.

As is best seen in FIGS. **25**, **27** and **29**, the right tapered region **416** (as viewed from a front of the power operated rotary knife **100**, that is, looking at the blade housing **400** from the perspective of an arrow labeled RW (designating a rearward direction) in FIG. **25**) of the blade housing mounting section **402** includes a cleaning port **480** for injecting cleaning fluid for cleaning the blade housing **400** and the knife blade **300** during a cleaning process. The cleaning port **480** includes an entry opening **481** in the outer wall **406** of the mounting section **402** and extends through to exit opening **482** in the inner wall **404** of the mounting section **402**. As can best be seen in FIG. **29**, a portion of the exit opening **482** in the mounting section inner wall is congruent with and opens into a region of the bearing race **460** of the blade housing **400**. The exit opening **482** in the mounting section inner wall **404** and radial gap G (FIG. **13**) between the blade **300** and the blade housing **400** provides fluid communication and injection of cleaning fluid into bearing race regions **320**, **460** of the knife blade **300** and blade housing **400**, respectively, and the driven gear **328** of the knife blade **300**.

Blade-Blade Housing Bearing Structure **500**

The power operated rotary knife **100** includes the blade-blade housing support or bearing structure **500** (best seen in FIGS. **2**A, **13** and **14**) that: a) secures the knife blade **300** to the blade housing **400**; b) supports the knife blade for rotation with respect to the blade housing about the rotational axis R; and c) defines the rotational plane RP of the knife blade. As noted previously, advantageously, the blade-blade housing support structure **500** of the present disclosure permits the use of a one-piece, continuous annular blade housing **400**. Additionally, the blade-blade housing bearing structure **500** provides for lower friction between the knife blade **300** and blade housing **400** compared to prior power operated rotary knife designs.

The lower friction afforded by the blade-blade housing bearing structure **500** advantageously permits the power operated rotary knife **100** of the present disclosure to be operated without the use of an additional, operator applied source of lubrication. Prior power operated rotary knives typically included a lubrication reservoir and bellows-type manual pump mechanism, which allowed the operator to inject an edible, food-grade grease from the reservoir into the blade-blade housing bearing region for the purpose of providing additional lubrication to the bearing region. When cutting or trimming a meat product, lubrication in the nature of fat/grease typically occurs as a natural by-product or result of cutting/trimming operations, that is, as the meat product is cut or trimmed the rotary knife blade cuts through fat/grease. As cutting/trimming operations continue and the rotary knife blade rotates within the blade housing, fat/grease from the meat product may migrate, among other places, into the blade-blade housing bearing region.

In the power operated rotary knife **100**, the fat/grease may migrate into the annular passageway **504** (FIG. **13**) defined by the opposing arcuate bearing faces **322**, **464** of the rotary knife blade bearing race **320** and the blade housing bearing race **460** as the knife **100** is used for meat cutting/trimming operations. However, in prior power operated rotary knives, this naturally occurring lubrication would typically be supplemented by the operator by using the pump mechanism to apply additional lubrication into the blade-blade housing region in an attempt to reduce blade-blade housing bearing friction, make the blade rotate easier, and reduce heating.

In one exemplary embodiment of the power operated rotary knife **100**, there is no reservoir of grease or manual pump mechanism to apply the grease. Elimination of the need for additional lubrication, of course, advantageously eliminates those components associated with providing lubrication (grease reservoir, pump, etc.) in prior power operated rotary knives. Elimination of components will reduce weight and/or reduce maintenance requirements associated with the lubrication components of the power operated rotary knife **100**. Lower friction between the knife blade **300** and the blade housing **400** decreases heat generated by virtue of friction between the rotary knife blade **300**, the blade-blade housing bearing structure **500** and the blade housing **400**. Reducing heat generated at the blade-blade housing bearing region has numerous benefits including mitigation of the aforementioned problem of "cooking" of displaced fragments of trimmed meat, gristle, fat, and bone that migrated into the blade-blade housing bearing region **504**. In prior power operated rotary knives, frictional contact between the blade and blade housing, under certain conditions, would generate sufficient heat to "cook" material in the blade-blade housing bearing region. The "cooked" material tended to accumulate in the blade-blade housing bearing region as a sticky build up of material, an undesirable result.

Additionally, the lower friction afforded by the blade-blade housing bearing structure **500** of the power operated rotary knife **100** has the additional advantage of potentially increasing the useful life of one or more of the knife blade **300**, the blade housing **400** and/or components of the gearbox **602**. Of course, the useful life of any component of the power operated rotary knife **100** is dependent on proper operation and proper maintenance of the power operated knife.

As can best be seen in FIGS. **14-17**, the blade-blade housing bearing structure **500** comprises an elongated rolling bearing strip **502** that is routed circumferentially through the annular passageway **504** about the axis of rotation R of the knife blade **300**. A rotary knife bearing assembly **552** (FIG. **13**) of the power operated rotary knife **100** includes the combination of the blade-blade housing bearing structure **500**, the blade housing bearing race **460**, the knife blade bearing race **320** and the annular passageway **504** defined therebetween. In an alternate exemplary embodiment, a plurality of elongated rolling bearing strips may be utilized, each similar to, but shorter in length than, the elongated bearing strip **502**. Utilizing a plurality of shorter elongated bearing strips in place of the single, longer elongated bearing strip **502** may be advantageous in that shorter elongated bearing strips are less difficult and less expensive to fabricate. If a plurality of elongated bearing strips are used, such strips would be sequentially inserted within the annular passageway **504** in head-to-tail fashion or in spaced apart relationship. The plurality of elongated bearing strips may include slightly enlarged end portions so that two adjacent bearing strips do not run together or to limit an extent of overlapping of two adjacent bearing strips.

In one exemplary embodiment, the central portion **462** of the blade housing bearing race **460** defines, in cross section, the substantially arcuate bearing face **464**. Similarly, the central portion **324** of the knife blade bearing race **320** defines, in cross section, the substantially arcuate bearing face **322**. As can best be seen in FIGS. **14-17**, the elongated rolling bearing strip **502**, in one exemplary embodiment, comprises the plurality of spaced apart rolling bearings **506** supported for rotation in the flexible separator cage **508**. In one exemplary embodiment, the flexible separator cage **508** comprises an elongated polymer strip **520**. The elongated polymer strip **520** defines a strip longitudinal axis SLA (FIG. **16**) and is generally rectangular when viewed in cross section. The strip **520** includes a first vertical axis SVA (FIG. **15**) that is orthogonal to the strip longitudinal axis SVA and a second horizontal axis SHA (FIG. **15**) orthogonal to the strip longitudinal axis SLA and the first vertical axis SVA. The strip first vertical axis SVA is substantially parallel to a first inner surface **522** and a second outer surface **524** of the strip **520**. As can be seen in FIG. **15**, the first inner surface **522** and the second outer surface **524** are generally planar and parallel. The strip second horizontal axis SHA is substantially parallel to a third top or upper surface **526** and a fourth bottom or lower surface **528** of the strip **520**.

Each of the plurality of ball bearings **506** is supported for rotation in a respective different bearing pocket **530** of the strip **520**. The bearing pockets **530** are spaced apart along the strip longitudinal axis SLA. Each of the strip bearing pockets **530** defines an opening **532** extending between the first inner surface **522** and the second outer surface **524**. Each of the plurality of bearing pockets **530** includes a pair of spaced apart support arms **534**, **536** extending into the opening **532** to contact and rotationally support a respective ball bearing of the plurality of ball bearings **506**. For each pair of support arms **534**, **536**, the support arms **534**, **536** are mirror images of each other. Each of the pairs of support arms **534**, **536** defines a pair of facing, generally arcuate bearing surfaces that rotationally support a ball bearing of the plurality of ball bearings **506**. Each of the pairs of support arms **534**, **536** includes an extending portion **538** that extends outwardly from the strip **520** beyond the first planar inner surface **522** and an extending portion **540** that extends outwardly from the strip **520** beyond the second planar outer surface **524**.

The plurality of ball bearings **506** of the elongated rolling bearing strip **502** are in rolling contact with and provide bearing support between the knife blade bearing race **320** and the blade housing bearing race **460**. At the same time, while supporting the knife blade **300** for low friction rotation with respect to the blade housing **400**, the elongated rolling bearing strip **502** also functions to secure the knife blade **300** with respect to the blade housing **400**, that is, the bearing strip **502** prevents the knife blade **300** from falling out of the blade housing **400** regardless of the orientation of the power operated rotary knife **100**.

When the rolling bearing strip **502** and, specifically, the plurality of ball bearings **506** are inserted into the passageway **504**, the plurality of ball bearings **506** support the knife blade **300** with respect to the blade housing **400**. In one exemplary embodiment, the plurality of ball bearings **506** are sized that their radii are smaller than the respective radii of the arcuate bearing surfaces **464**, **322**. In one exemplary embodiment, the radius of each of the plurality of ball bearings **506** is 1 mm. or approximately 0.039 inch, while radii of the arcuate bearing surfaces **464**, **322** are slightly larger, on the order of approximately 0.043 inch. However, it should be recognized that in other alternate embodiments, the radii of the plurality of ball bearings **506** may be equal to or larger than the radii of the arcuate bearing faces **464**, **322**. That is, the radii of the plurality of ball bearings **506** may be in a general range of between 0.02 inch and 0.07 inch, while the radii of the arcuate bearing surfaces **464**, **322** may be in a general range of between 0.03 inch and 0.06 inch. As can best be seen in FIG. **13**, when the rolling bearing strip **502** is inserted into the radial, annular gap G, the plurality of ball bearings **506** and a central portion **509***a* of the separator cage **508** are received in the annular passageway **504** defined between the opposing bearing surfaces **319**, **459** of the rotary knife blade **300** and the blade housing **400**. The annular passageway **504** comprises part of the annular gap G between the opposing outer wall **312** of the rotary knife blade body **302** and the inner wall **452** of the blade housing blade support section **450**. In one exemplary embodiment, the annular gap G is in a range of approximately 0.04-0.05 inch and is disposed between the vertical inner wall portion **452***a* of the blade support section **450** of the blade housing **400** and the facing vertical outer wall portion **340** of the outer wall **312** of the body **302** of the knife blade **300**, adjacent or in the region of the opposing bearing surfaces **319**, **459**.

As can be seen in FIG. **13**, the annular passageway **504** is generally circular in cross section and receives the plurality of ball bearings **506** and a central portion **509***a* of the separator cage **508** of the elongated rolling bearing strip **502**. When positioned in the annular passageway **504**, the elongated rolling bearing strip **502** and, specifically, the separator cage **508** of the rolling bearing strip **502**, forms substantially a circle or a portion of a circle within the annular passageway **504** centered about an axis that is substantially congruent with the rotary knife blade axis of rotation R. As the separator cage **508** of the rolling bearing strip **502** is vertically oriented in the gap G, the cage **508** includes top and bottom portions **509***b* extending from the central portion **509***a*. As can be seen in FIG. **13**, the top and bottom portions **509***b* of the separator cage **508** extend axially slightly above and slightly below the plurality of ball bearings **506**. When positioned in the annular passageway **504**, the elongated rolling bearing strip **502** forms substantially a circle or a portion of a circle within the annular passageway **504** centered about an axis that is substantially congruent with the rotary knife blade axis of rotation R, while the separator cage **508** forms substantially a cylinder or a portion of a cylinder with the gap G centered about the rotary knife blade axis of rotation R.

As can be seen in FIG. **13**, the separator cage **508**, in cross section, is rectangular and is oriented in an upright position within the gap G, the separator cage **508** may be viewed as forming substantially a cylinder or a partial cylinder within the gap G centered about the rotary knife blade axis of rotation R. The plurality of ball bearings **506** ride within the annular passageway **504**, which is substantially circular in cross section and is centered about the blade axis of rotation R.

To minimize friction, it is not desirable for the flexible separator cage **508** to be in contact with or in bearing engagement with either the rotary knife blade **300** or the blade housing **400** as this would unnecessarily generate sliding friction. What is desired is for the rotary knife blade **300** to be solely supported with respect to the blade housing **400** via rolling bearing support provided by the plurality of ball bearings **506** of the rolling bearing strip **502** bearing against the opposing arcuate bearing faces **322**, **464** of the rotary knife blade **300** and the blade housing **400**. Accordingly, as can best be seen in the sectional view of FIG. **13**, the flexible separator cage **508** is configured to ride in the annular passageway **504** and in the annular gap G without substantial contact with either the knife blade **300** or the blade housing **400** or the opposing bearing surfaces **319**, **459** of the knife blade **300** and blade housing **400**. In one exemplary embodiment, a width of the upper and lower portions **509***b* of the separator cage **508** is on the order of 0.03 inch and, as mentioned previously, the annular gap G is on the order of 0.04-0.05 inch. Thus, when the rolling bearing strip **502** is inserted into the annular passageway **504**, a clearance of approximately 0.005-0.010 inch exists between the separator cage **508** and the facing vertical outer wall portion **340** of the outer wall **312** of the body **302** of the knife blade **300**, adjacent the opposing bearing surfaces **319**, **459**. Depending on the specific length of the separator cage **508** and the circumference of the gap G, the ends **510**, **512** of the separator cage **508** may be spaced apart slightly (as is shown in FIG. **14**), may be in contact, or may be slightly overlapping.

It should be appreciated that when the rotary knife blade **300** is rotated by the drive train **604** at a specific, desired RPM, the separator cage **508** also moves or translates in a circle along the annular gap G, although the rotational speed of the separator cage **508** within the gap G is less than the RPM of the rotary knife blade **300**. Thus, when the power operated rotary knife **100** is in operation, the elongated rolling bearing strip **502** traverses through the annular passageway **504** forming a circle about the knife blade axis of rotation R. Similarly, when the power operated rotary knife **100** is in operation, the separator cage **508**, due to its movement or translation along the annular gap G about the knife blade axis of rotation R, can be considered as forming a complete cylinder within the gap G. Additionally, when the rotary knife blade **300** is rotated, the plurality of ball bearings **506** both rotate with respect to the separator cage **506** and also move or translate along the annular passageway **504** about the knife blade axis of rotation R as the separator cage **508** moves or translates along the annular gap G. Upon complete insertion of the rolling bearing strip **502** into the gap G, the assembled blade-blade housing combination **550** (FIGS. **9** and **10**) is then ready to be secured, as a unit, to the frame body **150** of the head assembly **111**.

Rolling bearing strips of suitable configuration are manufactured by KMF of Germany and are available in the United States through International Customized Bearings, 200 Forsyth Dr., Ste. E, Charlotte, N.C. 28237-5815.

Securing the Knife Blade **300** to the Blade Housing **400**

The blade-blade housing bearing structure **500** is utilized to both secure the rotary knife blade **300** to the blade housing **400** and to rotatably support the blade **300** within the blade housing **400**. To insert the elongated rolling bearing strip **502** of the blade-blade housing bearing structure **500** the passageway **504** formed between the radially aligned, opposing arcuate bearing faces **322**, **464** of the blade bearing race **320** and the blade housing bearing race **460**, the blade housing plug **430** is removed from the blade housing plug opening **429** of the blade housing **400**. Then, the rolling bearing strip **502** is routed between the knife blade **300** and the blade housing **400** into the annular gap G and through the passageway **504**. Next, the blade housing plug **430** is inserted in the blade housing plug opening **429** and the plug **430** is secured to the blade housing **400**. The blade-blade housing combination **550** then ready to be secured to the arcuate mounting pedestal **152** of the frame body **150**.

As can be seen in FIGS. **18-21** and in the flow diagram set forth in FIG. **58**, a method of securing the rotary knife blade **300** to the blade housing **400** for rotation with respect to the blade housing **400** about the blade axis of rotation R is shown generally at **900** in FIG. **58**. The method **900** includes the following steps. At step **902**, remove the blade housing plug **430** from the blade housing plug opening **429**. At step **904**, position the rotary knife blade **300** in blade housing **400** in an upright position such that blade **300** is supported by blade housing **400**. Specifically, the knife blade **300** is positioned in the blade housing **400** in an upright orientation such that the horizontal extending portion **342** of the outer wall **312** of the knife blade **300** and the bottom surface **345** of the knife blade set of gear teeth **330** are disposed on the respective first and second ledges **470**, **472** of the blade housing **400**. In this upright orientation, the blade housing bearing race **460** and the knife blade bearing race **320** are substantially radially aligned such that the annular passageway **504** is defined between the blade housing bearing race **460** and the knife blade bearing race **320**.

At step **906**, as is shown schematically in FIG. **18**, position the first end **510** of flexible separator cage **508** of rolling bearing strip **502** in blade housing plug opening **429** such that first end **510** is tangentially aligned with the gap G between the blade **300** and the blade housing **400** and the bearings **506** of the rolling bearing strip **502** are aligned with the annular passageway **504** between the opposing arcuate bearing faces **322**, **464** of the blade **300** and blade housing **400**. At step **908**, advance the flexible separator cage **508** tangentially with respect to the gap G such that bearings **506** of the rolling bearing strip **502** enter and move along the passageway **504**. That is, as is shown schematically in FIG. **19**, the separator cage **508** is advanced such that the separator cage **508** is effectively threaded through the passageway **504** and the gap G. The separator cage **508** is oriented in an upright position such that the cage fits into the gap G between the knife blade **300** and the blade housing **400**.

At step **910**, continue to advance the flexible separator cage **508** until first and second ends **510**, **512** of the separator cage **508** are substantially adjacent (FIG. **20**), that is, the separator cage **508** forms at least a portion of a circle within the passageway **504** and the gap G (like the circle C formed by the separator cage **508** schematically shown in FIG. **2**A). A longitudinal extent of the separator cage **508** of the elongated strip **502** along the strip longitudinal axis SLA is sufficient such that when the strip **502** is installed in the passageway **504**, the first and second ends **510**, **512** of the strip separator cage **508**, if not in contact, are slightly spaced apart as shown, for example in FIGS. **2**A and **14**. That is, the upright strip cage

508 when installed in the passageway 504 forms at least a portion of a cylinder within the passageway 504 and the gap G. At step 912 and as is shown schematically in FIG. 21, insert the blade housing plug 430 in blade housing opening 429 and secure blade housing plug to blade housing 400 with the fasteners 432.

As the rotary knife blade 400 is rotated by the gear train 604, the elongated rolling bearing strip 502 will travel in a circular route or path of travel within the gap 0, that is, the plurality of spaced apart ball bearings 506 will move in a circle though the annular passageway 504. However, because the individual bearings are also rotating within the separator cage 508 as the separator cage 508 moves in a circular route in the gap G, the rotational speed or angular velocity of the separator cage 508 is significantly less than the rotation speed or angular velocity of the rotary knife blade 300 with respect to the blade housing 400.

It should be appreciated that not all of the mating or coacting bearing surfaces of the rotary knife bearing assembly 552 including of the plurality of ball bearings 506 of the elongated rolling bearing strip 502, the rotary knife blade bearing race 320, the blade housing bearing race 460, and the blade housing plug bearing race portion 442, as described above, are in contact at any given time because there are necessarily running or operating clearances between the bearing strip rotary knife blade 300, the blade housing 400, and the blade housing plug 430 which allow the blade 300 to rotate relatively freely within the blade housing 400.

These running or operating clearances cause the rotary knife blade 300 to act somewhat akin to a teeter-totter within the blade housing 400, that is, as one region of the blade 300 is pivoted or moved upwardly within the blade housing 400 during a cutting or trimming operation, the diametrically opposite portion of the blade (180° away) is generally pivoted or moved downwardly within the blade housing. Accordingly, the specific mating bearing surfaces of the rotary blade bearing assembly 552 in contact at any specific location of the rotary knife blade 300, the blade housing 400, or the elongated bearing strip 502 will change and, at any given time, will be determined, at least in part, by the forces applied to the rotary knife blade 300 during use of the power operated rotary knife 100. Thus, for any specific portion or region of a bearing surface of the rotary blade bearing assembly 552, there may be periods of non-contact or intermittent contact with a mating bearing surface.

Removal of the rotary knife blade 300 from the blade housing 400 involves the reverse of the procedure discussed above. Namely, the blade housing plug 430 is removed from the blade housing 400. The rotary knife blade 300 is rotated with respect to the blade housing 400 until the adjacent ends 510, 512 of the separator cage 508 are visible within the blade housing plug opening 429. A small instrument, such as a small screwdriver, is used to contact and direct or pry one end of the separator cage 508, say, the first end 510 of the separator cage 508, tangentially away from the gap G. Rotation of the rotary knife blade 300 is continued until a sufficient length of the separator cage 508 is extending tangentially away from the gap G and through the blade housing plug opening 429 such that the end 510 of the separator cage 508 may be grasped by the fingers of the operator. The separator cage 508 is then pulled from the gap G. Once the cage 508 has been completely removed from the gap G between the rotary knife blade 300 and the blade housing 400, the blade housing 400 is turned upside down and the rotary knife blade 300 will fall out of the blade housing 400.

Cutting Profile of Blade-Blade Housing Combination 550

The friction or drag experienced by the operator as the power operated rotary knife 100 is manipulated by the operator to move through a product P, as schematically illustrated in FIGS. 54 and 55, is dependent, among other things, on the cross sectional shape or configuration of the blade-blade housing combination 550 in a cutting region CR of the assembled combination 550. As can best be seen in FIG. 3, the cutting region CR of the blade-blade housing combination 550 is approximately 240° of the entire 360° periphery of the combination. The cutting region CR excludes the approximately 120° of the periphery of the blade-blade housing combination 550 occupied by the mounting section 402 of the blade housing 400.

As can best be seen in FIGS. 54 and 55, the blade-blade housing combination 550 is configured and contoured to be as smooth and continuous as practical. As can best be seen in FIG. 54, a layer L1 of material is cut or trimmed from a product P being processed (for example, a layer of tissue, for example, a layer of meat or fat trimmed from an animal carcass) by moving the power operated rotary knife 100 in a cutting direction CD such that the rotating knife blade 300 and blade housing 400 move along and through the product P to cut or trim the layer of material L1. As the power operated rotary knife 100 is moved by the operator, the blade edge 350 cuts the layer L1 forming a cut portion CL1 of the layer L1. The cut portion CL1 moves along a cut or trimmed material path of travel PT through the cutting opening CO of the blade-blade housing combination 550 as the power operated rotary knife 100 advances through the product P.

A new outer surface layer NS (FIG. 55) formed as the layer L1 is cut away from the product P. The cut portion CL1 of the layer L1 slides along the inner wall 360 of the rotary knife blade 300, while new outer surface layer NS slides along the respective outer walls 356, 454 of the blade section 350 of the knife blade 300 and the blade support section 450 of the blade housing 400.

A smooth transition between the blade section outer wall 356 of the knife blade 300 and the blade support section outer wall 454 of the blade housing 400 is provided by the short, radially extending driven gear cap portion 466 of the blade housing 400 and the radially extending shoulder 308*a* of the lower end 308 of the rotary knife blade body 302. The close proximity of the radially extending end 467 of the driven gear cap portion 466 provides a labyrinth seal to impede ingress of foreign materials into the region of the knife blade driven gear 328 and the region of the blade-blade housing bearing structure 500. Finally, the blade-blade housing combination 550 in the cutting region CR is shaped to extent possible to reduce drag and friction experienced by the operator when manipulating the power operated rotary knife in performing cutting or trimming operations.

Gear Train 604

The drive mechanism 600 of the power operated rotary knife 100 includes certain components and assemblies internal to the power operated rotary knife 100 including the gear train 604 and the driven gear 328 of the rotary knife blade 300 and certain components and assemblies external to the power operated rotary knife 100 including the drive motor 800 and the flexible shaft drive assembly 700, which is releasably coupled to the knife 100, via the drive shaft latching assembly 275.

Within the power operated rotary knife 100, the drive mechanism 600 includes the gearbox 602 comprising the gear train 604. In one exemplary embodiment, the gear train 604 includes the pinion gear 610 and the drive gear 650. The drive gear 650, in turn, engages the driven gear 328 of the rotary knife blade 300 to rotate the knife blade 300. As noted previously, the gearbox drive gear **650**, in one exemplary embodiment, is a double gear that includes an upper, vertically or axially oriented bevel gear **652** and a lower, horizontally or radially oriented spur gear **654**. The drive gear upper bevel gear **652** engages and is rotatably driven by the pinion gear **610**. The drive gear lower spur gear **654** defines a plurality of drive gear teeth **656** that are mating involute gear teeth that mesh with the involute gear teeth **332** of the rotary knife blade driven gear **328** to rotate the rotary knife blade **300**. This gearing combination between the drive gear **650** and the rotary knife blade **300** defines a spur gear involute gear drive **658** (FIG. **8**A) to rotate the rotary knife blade **300**.

In the involute gear drive, the profiles of the rotary knife gear teeth **332** of the rotary knife blade **300** and the gear teeth **656** of the spur gear **654** of the drive gear **650** are involutes of a circle and contact between any pair of gear teeth occurs at a substantially single instantaneous point. Rotation of the drive gear **650** and the knife blade driven gear **328** causes the location of the contact point to move across the respective tooth surfaces. The motion across the respective gear tooth faces is a rolling type of contact, with substantially no sliding involved. The involute tooth form of rotary knife blade gear teeth **332** and the spur gear gear teeth **656** results in very little wear of the respective meshing gear teeth **332**, **656** versus a gearing structure wherein the meshing gear teeth contact with a sliding motion. The path traced by the contact point is known as the line of action. A property of the involute tooth form is that if the gears are meshed properly, the line of action is straight and passes through the pitch point of the gears. Additionally, the involute gear drive **658** is also a spur gear drive which means that an axis of rotation DGR (shown in FIGS. **8** and **8**A) of the drive gear **650** is substantially parallel to the axis of rotation R of the knife blade **300**. Such a spur drive with parallel axes of rotation DGR, R is very efficient in transmitting driving forces. The spur drive gearing arrangement of the rotary knife blade gear teeth **332** and the spur gear drive teeth **656** also advantageously contributes to reducing the wear of the meshing gears **332**, **656** compared with other more complex gearing arrangements.

The pinion gear **610** comprises an input shaft **612** and a gear head **614** that extends radially outwardly from the input shaft **612** and defines a set of bevel gear teeth **616**. The input shaft **612** extends in a rearward direction RW along the handle assembly longitudinal axis LA and includes a central opening **618** extending in a forward direction FW from a rearward end **629** (FIG. **41**) to a forward end **628** of the input shaft **612**, the central opening **618** terminating at the gear head **614**. An inner surface **620** of the input shaft **612** defines a cross-shaped female socket or fitting **622** (FIGS. **37** and **40**) which receives a mating male drive fitting **714** (FIG. **53**) of the shaft drive assembly **700** to rotate the pinion gear **610** about an axis of rotation PGR which is substantially congruent with the handle assembly longitudinal axis LA and intersects the knife blade axis of rotation R.

The pinion gear **610** is supported for rotation about the pinion gear axis of rotation PGR (FIGS. **8** and **8**A) by the bearing support assembly **630**, which, in one exemplary embodiment, includes a larger sleeve bushing **632** and a smaller sleeve bushing **640** (FIG. **42**). As can best be seen in FIG. **41**, a forward facing surface **624** of the gear head **614** of the pinion gear **610** includes a central recess **626** which is substantially circular in cross section and is centered about the pinion gear axis of rotation PGR. The pinion gear central recess **626** receives a cylindrical reward portion **642** of the smaller sleeve bushing **640**. The smaller sleeve bushing **640** functions as a thrust bearing and includes an enlarged annular head **644** provides a bearing surface for the pinion gear gear head **614** and limits axial travel of the pinion gear **610** in the forward direction FW, that is, travel of the pinion gear **610** along the pinion gear axis of rotation PGR, in the forward direction FW.

The sleeve bushing **640** is supported on a boss **158***b* (FIGS. **49** and **50**) of the frame body **150**. Specifically, the boss **158***b* extends rearwardly from an inner surface **158***a* of a forward wall **154***a* of a central cylindrical region **154** of the frame body **150**. The boss **158***b* of the frame body central cylindrical region **154** includes a flat **158***c* that interfits with a flat **648** (FIG. **2**C) formed in a central opening **646** of the sleeve bushing **640** to prevent rotation of the sleeve bushing **640** as the pinion gear **610** rotates about its axis of rotation PGR.

In one exemplary embodiment, the gear head **614** of the pinion gear **610** includes 25 bevel gear teeth and, at the forward facing surface **624**, has an outside diameter of approximately 0.84 inch (measured across the gear from the tops of the gear teeth) and a root diameter of approximately 0.72 inch (measured across a base of the teeth). The bevel gear teeth **616** taper from a larger diameter at the forward facing surface **624** to a smaller diameter in away from the forward facing surface **624**.

The larger sleeve bushing **632** of the pinion gear bearing support assembly **630** includes a central opening **634** that receives and rotatably supports the pinion gear input shaft **612**. The larger sleeve bushing **632** includes an enlarged forward head **636** and a cylindrical rearward body **637**. The cylindrical rearward body **637** of the larger sleeve bushing **632** is supported within a conforming cavity **129** (FIGS. **39** and **48**) of the inverted U-shaped forward section **118** of the gearbox housing **113**, while the enlarged forward head **636** of the sleeve bushing **632** fits within a conforming forward cavity **126** of the U-shaped forward section **118** of the gearbox housing **113**.

A flat **638** (FIG. **41**) of the enlarged forward head **636** of the larger sleeve bushing **632** interfits with a flat **128** of the U-shaped forward section **118** of the gearbox housing **113** to prevent rotation of the sleeve bushing **632** within the gearbox housing **113**. The cylindrical body **639** of the larger sleeve bushing **632** defining the central opening **634** provides radial bearing support for the pinion gear **610**. The enlarged head **636** of the sleeve bushing **632** also provides a thrust bearing surface for the rearward collar **627** of the gear head **614** to prevent axial movement of the pinion gear **610** in the rearward direction RW, that is, travel of the pinion gear **610** along the pinion gear axis of rotation PGR, in the rearward direction RW. Alternatively, instead of a pair of sleeve bushings **632**, **640**, the bearing support assembly **630** for the pinion gear **610** may comprise one or more roller or ball bearing assemblies or a combination of roller/ball bearing assemblies and sleeve bearings.

The drive gear **650**, in one exemplary embodiment, is a double gear with axially aligned gears including the first bevel gear **652** and the second spur gear **654**, both rotating about a drive gear axis of rotation DGR (FIGS. **8** and **8**A). The drive gear axis of rotation DGR is substantially orthogonal to and intersects a pinion gear axis of rotation PGR. Further, the drive gear axis of rotation DGR is substantially parallel to the knife blade axis of rotation R. The first gear **652** is a bevel gear and includes a set of bevel gear teeth **653** that mesh with the set of bevel gear teeth **616** of the gear head **614** of the pinion gear **610**. As the pinion gear **610** is rotated by the shaft drive assembly **700**, the bevel gear teeth **616** of the pinion gear **610**, in turn, engage the bevel gear teeth **653** of the first gear **652** to rotate the drive gear **650**.

The second gear **654** comprises a spur gear including a set of involute gear teeth **656**. The spur gear **654** engages and drives the driven gear **328** of the knife blade **300** to rotate the knife blade about its axis of rotation R. Because the spur gear **654** of the gearbox **602** and the driven gear **328** of the knife blade **300** have axes of rotation DGR, R that are parallel (that is, a spur gear drive) and because the gears **654**, **328** comprise an involute gear drive **658**, there is less wear of the respective gear teeth **656**, **332** than in other gear drives wherein the axes of rotation are not parallel and wherein a non-involute gear drive is used. In one exemplary embodiment, the first gear **652** includes 28 bevel gear teeth and has an outside diameter of approximately 0.92 inch and an inside diameter of approximately 0.66 inch and the second gear **654** includes 58 spur gear teeth and has an outside diameter of approximately 1.25 inches and a root diameter of approximately 1.16 inches.

The drive gear **650** is supported for rotation by the bearing support assembly **660** (FIGS. **39-43**). The bearing support assembly **660**, in one exemplary embodiment, comprises a ball bearing assembly **662** that supports the drive gear **650** for rotation about the drive gear rotational axis DGR. The drive gear bearing support assembly **660** is secured to a downwardly extending projection **142** (FIGS. **47** and **48**) of the inverted U-shaped forward section **118** of the gearbox housing **113**. As can be seen in FIG. **39**, the ball bearing assembly **662** includes a plurality of ball bearings **666** trapped between an inner race **664** and an outer race **668**. The outer race **668** is affixed to the drive gear **650** and is received in a central opening **670** of the drive gear **650**. The inner race **664** is supported by the fastener **672**. A threaded end portion of the fastener **672** and screws into a threaded opening **140** (FIGS. **41** and **47**) defined in a stem **143** of the downwardly extending projection **142** of the inverted U-shaped forward section **118** of the gearbox housing **113**. The fastener **672** secures the ball bearing assembly **662** to the gearbox housing **113**. Alternatively, instead of a ball bearing assembly, the bearing support assembly **660** may comprise one or more sleeve bearings or bushings.

Gearbox Housing **113**

As is best seen in FIGS. **2**C, and **33-44**, the gearbox assembly **112** includes the gearbox housing **113** and the gearbox **602**. As can best be seen in FIGS. **41-48**, the gearbox housing **113** includes a generally cylindrical rearward section **116** (in the rearward direction RW away from the blade housing **400**), an inverted U-shaped forward section **118** (in the forward direction FW toward the blade housing **400**) and a generally rectangular base section **120** disposed axially below the forward section **118**. The gearbox housing **113** includes the gearbox cavity or opening **114** which defines a throughbore **115** extending through the gearbox housing **113** from a rearward end **122** to a forward end **124**. The throughbore **115** extends generally along the handle assembly longitudinal axis LA. The inverted U-shaped forward section **118** and the cylindrical rearward section **116** combine to define an upper surface **130** of the gearbox housing **113**.

The gearbox housing **113** also includes a generally rectangular shaped base **120** which extends downwardly from the inverted U-shaped forward section **118**, i.e., away from the upper surface **130**. The rectangular base **120** includes a front wall **120***a* and a rear wall **120***b*, as well as a bottom wall **120***c* and an upper wall **120***d*, all of which are generally planar. As is best seen in FIGS. **47** and **48**, extending radially inwardly into the front wall **120***a* of the rectangular base **120** are first and second arcuate recesses **120***e*, **120***f*. The first arcuate recess **120***e* is an upper recess, that is, the upper recess **120***e* is adjacent a bottom portion **141** of the inverted U-shaped forward section **118** and, as best seen in FIG. **43**, is offset slightly below the upper wall **120***d* of the rectangular base **120**. The second arcuate recess **120***f* is a lower recess and extends through the bottom wall **120***c* of the rectangular base **120**.

The bottom portion **141** of the inverted U-shaped forward section **118** includes a downwardly extending projection **142** (FIG. **47**). The downwardly extending projection **142** includes a cylindrical stem portion **143** and defines a threaded opening **140** extending through the projection **142**. A central axis through the threaded opening **140** defines and is coincident with the axis of rotation DGR of the drive gear **650**. The upper and lower arcuate recesses **120***e*, **120***f* are centered about the drive gear axis of rotation DGR and the central axis of the threaded opening **140**.

The throughbore **115** of the gearbox housing **113** provides a receptacle for the pinion gear **610** and its associated bearing support assembly **630** while the upper and lower arcuate recesses **120***e*, **120***f* provide clearance for the drive gear **650** and its associate bearing support assembly **660**. Specifically, with regard to the bearing support assembly **630**, the cylindrical body **637** of the larger sleeve bushing **632** fits within the cylindrical cavity **129** of the inverted U-shaped forward section **118**. The enlarged forward head **636** of the sleeve bushing **632** fits within the forward cavity **126** of the forward section **118**. The cylindrical cavity **129** and the forward cavity **126** of the inverted U-shaped forward section **118** are both part of the throughbore **115**.

With regard to the upper and lower arcuate recesses **120***e*, **120***f*, the upper recess **120***e* provides clearance for the first bevel gear **652** of the drive gear **650** as the drive gear **650** rotates about its axis of rotation DGR upon the first bevel gear **652** being driven by the pinion gear **610**. The wider lower recess **120***f* provides clearance for the second spur gear **654** of the drive gear **650** as the spur gear **654** coacts with the driven gear **328** to rotate the rotary knife blade **300** about its axis of rotation R. As can best be seen in FIGS. **39** and **40**, the downwardly extending projection **142** and stem **143** provide seating surfaces for the ball bearing assembly **662**, which supports the drive gear **650** for rotation within the rectangular base **120** of the gearbox housing **113**. A cleaning port **136** (FIGS. **47** and **48**) extends through the bottom portion **141** of inverted U-shaped forward section **118** and a portion of the base **120** of the gearbox housing **113** to allow cleaning fluid flow injected into the throughbore **115** of the gearbox housing **113** from the proximal end **122** of the gearbox housing **113** to flow into the upper and lower arcuate recesses **120***e*, **120***f* for purpose of cleaning the drive gear **650**.

As can be seen in FIGS. **39** and **40**, an inner surface **145** of the cylindrical rearward section **116** of the gearbox housing **113** defines a threaded region **149**, adjacent the proximal end **122** of the gearbox housing **113**. The threaded region **149** of the gearbox housing **113** receives a mating threaded portion **262** (FIG. **2**B) of the elongated central core **252** of the hand piece retaining assembly **250** to secure the hand piece **200** to the gearbox housing **113**.

As seen in FIGS. **38-44**, an outer surface **146** of the cylindrical rearward section **116** of the gearbox housing **113** defines a first portion **148** adjacent the proximal end **122** and a second larger diameter portion **147** disposed forward or in a forward direction FW of the first portion **148**. The first portion **148** of the outer surface **146** of the cylindrical rearward portion **116** of the gearbox housing **113** includes a plurality of axially extending splines **148***a*. The plurality of splines **148***a* accept and interfit with four ribs **216** (FIG. **2**B) formed on an inner surface **201** of a distal end portion **210** of the hand piece **200**. The coacting plurality of splines **148***a* of the gearbox housing **113** and the four ribs **216** of the hand piece **200** allow the hand piece **200** to be oriented at any desired rotational position with respect to the gearbox housing **113**.

The second larger diameter portion **147** of the outer surface **146** of the cylindrical rearward section **116** of the gearbox housing **113** is configured to receive a spacer ring **290** (FIG. 2B) of the hand piece retaining assembly **250**. As can be seen in FIG. **8**A, the spacer ring **290** abuts and bears against a stepped shoulder **147***a* defined between the cylindrical rearward section **116** and the inverted U-shaped forward section **118** of the gearbox housing **113**. That is, an upper portion **134** of the inverted U-shaped forward section **118** is slightly radially above a corresponding upper portion **132** of the cylindrical rearward section **116** of the gearbox housing **113**. A rear or proximal surface **292** (FIG. 2B) of the spacer ring **290** acts as a stop for an axially stepped collar **214** of the distal end portion **210** of the hand piece **200** when the hand piece **200** is secured to the gearbox housing **113** by the elongated central core **252** of the hand piece retaining assembly **250**.

The second larger diameter portion **147** of the outer surface **146** also includes a plurality of splines (seen in FIGS. **41** and **46**). The plurality of splines of the second portion **147** are used in connection with an optional thumb support (not shown) that may be used in place of the spacer ring **290**. The thumb support provides an angled, outwardly extending support surface for the operator's thumb. The plurality of splines of the second portion **147** are utilized in connection with the optional thumb support to allow the operator to select a desired rotational orientation of the thumb support with respect to the gearbox housing **113** just as the plurality of splines **148***a* of the first portion **148** allow the operator to select a desired rotational orientation of the hand piece **200** with respect to the gearbox housing **113**.

Frame Body **150**

Also part of the head assembly **111** is the frame or frame body **150**, best seen in FIGS. **45** and **49-52**. The frame body **150** receives and removably supports both the gearbox assembly **112** and the blade-blade housing combination **550**. In this way, the frame body **150** releasably and operatively couples the gearbox assembly **112** to the blade-blade housing combination **550** such that the gear train **604** of the gearbox assembly **112** operatively engages the driven gear **328** of the rotary knife blade **300** to rotate the knife blade **300** with respect to the blade housing **400** about the axis of rotation R.

The frame body **150** includes the arcuate mounting pedestal **152** disposed at a forward portion **151** (FIG. 2C) of the frame **150**, the central cylindrical region **154**, and a rectangular base **180** (FIG. **51**) disposed below the central cylindrical region **154**. The arcuate mounting pedestal **152** of the frame body defines the seating region **152***a* (FIGS. 2C and **51**) to receive the mounting section **402** of the blade housing **400** and secure the blade-blade housing combination **550** to the frame body **150**. The central cylindrical region **154** and the rectangular base **180** of the frame body **150** define a cavity **155** (FIGS. **45** and **49**) which slidably receives the gearbox housing **113**. The frame body cavity **155** is comprised of an upper socket **156** defined by the central cylindrical region **154** and a lower horizontally extending opening **190** defined by and extending through the central rectangular base **180**.

The central rectangular base **180** of the frame body **150** includes a bottom wall **182** and a pair of side walls **184** that extend upwardly from the bottom wall **182**. As is best seen in FIGS. **49** and **50**, a pair of bosses **186** extend inwardly from the pair of side walls **184**. Rearward facing surfaces **187** of the pair of bosses **186** each include a threaded opening **188**. The lower horizontally extending opening **190** defined by the rectangular base **180** includes two parts: a generally rectangular portion **190***a* extending rearwardly from the pair of boss surfaces **187**; and a forward portion **190***b* that extends through the rectangular base **180** to the seating region **152***a* of the frame body **150**.

To secure the gearbox assembly **112** to the frame body **150**, the gearbox assembly **112** is aligned with and moved toward a proximal end **157** of the frame body **150**. As can best be seen in FIG. **45**, the socket **156** defined by the central cylindrical region **154** of the frame body **150** is configured to slidably receive the inverted U-shaped forward section of the gearbox housing **113** and the rectangular portion **190***a* of the horizontally extending opening **190** of the rectangular base **180** is configured to slidably receive the rectangular base **120** of the gearbox housing **113**. The upper surface **130** of the gearbox housing **113** is slidably received within the inner surface **158** of the central cylindrical region **154** of the frame body **150**.

When the gearbox assembly **112** is fully inserted into the frame body **150**, the front wall **120***a* of the base **120** of the gearbox housing **113** abuts the rearward facing surfaces **187** of the pair of bosses **186** of the rectangular base **180** of the frame body **150**. Further, the horizontally extending openings **121** of the gearbox housing base **120** are aligned with the horizontally extending threaded openings **188** of the pair of bosses **186** of the frame body rectangular base **180**. A pair of threaded fasteners **192** (FIG. **45**) pass through the openings **121** of the gearbox housing base **120** and thread into the threaded openings **188** of the pair of bosses **186** of the frame body rectangular base **180** to releasably secure the gearbox assembly **112** to the frame body **150**. The openings **121** of the gearbox housing base **120** are partially threaded to prevent the fasteners **192** from fall out of the openings **121** when the gearbox housing **113** is not coupled to the frame body **150**.

The openings **121** of the gearbox housing base **120** include countersunk end portions **121***a* (FIG. **45**) to receive the enlarged heads of the pair of threaded fasteners **192** such that the enlarged heads of the fasteners **192**, when tightened into the frame body **150**, are flush with the rear wall **120***b* of the base **120**. The threaded fasteners **192** include narrow body portions relative to the enlarged heads and larger diameter threaded portions such that the fasteners **192** remain captured within their respective gearbox housing openings **121** when the gearbox housing **113** is not coupled to the frame body **150**. Relative movement between the gearbox assembly **112** and the frame body **150** is constrained by the threaded interconnection of the gearbox housing **113** to the frame body **150** via the threaded fasteners **192** and the abutting surfaces of the rectangular base **120** of the gearbox housing **113** and the rectangular base **180** of the frame body **150**.

Additionally, the frame body **150** releasably receives the blade-blade housing combination **550** and thereby operatively couples the blade-blade housing combination **550** to the gearbox assembly **112**. As can best be seen in FIGS. **51** and **52**, the pair of arcuate arms **160**, **162** of the frame body **150** define the arcuate mounting pedestal **152**. The mounting pedestal **152**, in turn, defines the seating region **152***a* that releasably receives the mounting section **402** of the blade housing **400**. Specifically, the arcuate mounting pedestal **152** includes an inner wall **174**, an upper wall **176** extending radially in the forward direction FW from an upper end of the inner wall **174**, and a lower wall or ledge **178** extending radially in a forward direction FW from a lower end of the inner wall **174**.

When the blade housing mounting section **402** is properly aligned and moved into engagement with the frame body arcuate mounting pedestal **152**: 1) the outer wall **406** of the blade housing mounting section **402** bears against the mounting pedestal inner wall **174** of the frame body **150**; 2) the first upper end **408** of the blade housing mounting section **402** bears against the mounting pedestal upper wall **176** of the frame body **150**; and 3) a radially inwardly stepped portion **406***a* of the outer wall **406** of the blade housing mounting section **402** bears against an upper face and a forward face of the radially outwardly projecting mounting pedestal lower wall or ledge **178** of the frame body **150**.

The respective threaded fasteners **170**, **172** of the frame body **150** are threaded into the threaded openings **420***a*, **422***a* of the mounting inserts **420**, **422** of the blade housing mounting section **402** to secure the combination blade-blade housing **550** to the frame body **150**. Assuming that the gearbox assembly **112** is coupled to the frame body **150**, when the blade-blade housing combination **550** is secured to the frame body **150**, the second spur gear **654** of the drive gear **650** of the gearbox assembly **112** engages and meshes with the driven gear **328** of the rotary knife blade **300** of the blade-blade housing combination **550**. Thus, when the gearbox assembly **112** and the blade-blade housing combination **550** are secured to the frame body **150**, the gear train **604** of the gearbox assembly **112** is operatively engaged with the driven gear **328** of the rotary knife blade **300** to rotatably drive the blade **300** within the blade housing **400** about the blade axis of rotation R. Like the threaded fasteners **192** of the gearbox housing **113** that secure the gearbox housing **113** to the frame body **150**, the threaded fasteners **170**, **172** of the frame body **150** include narrow bodies and larger diameter threaded portions such that the fasteners remain captured in the partially threaded openings **160***a*, **162***a* of the arcuate arms **160**, **162**.

To remove the combination blade-blade housing **550** from the frame body **150**, the pair of threaded fasteners **170**, **172** of the frame body **150** are unthreaded from the threaded openings **420***a*, **422***a* of the blade housing mounting inserts **420**, **422**. Then, the blade-blade housing combination **550** is moved is the forward direction FW with respect to the frame body **150** to disengage the blade-blade housing combination **550** from the head assembly **111**.

A forward wall **154***a* of the central cylindrical region **154** of the frame body **150** includes a projection **198** that supports a steeling assembly **199** (FIG. 2C). The steeling assembly **199** includes a support body **199***a*, spring biased actuator **199***b*, and a push rod **199***c* with a steeling member **199***d* affixed to a bottom of the push rod **199***c*. The steeling assembly support body **199***a* is affixed to the projection **198**. When the actuator **199***b* is depressed by the operator, the push rod **199***c* moves downwardly and the steeling member **199***d* engages the blade edge **350** of the knife blade **300** to straighten the blade edge **350**.

Hand Piece **200** and Hand Piece Retaining Assembly **250**

The handle assembly **110** includes the hand piece **200** and the hand piece retaining assembly **250**. As can be seen in FIG. 2B, the hand piece **200** includes the inner surface **201** and the outer gripping surface **204**. The inner surface **201** of the hand piece **200** defines the axially extending central opening or throughbore **202**. The outer gripping surface **204** of the hand piece **200** extends between an enlarged proximal end portion **206** and the distal end portion **210**. A front face or wall **212** of the hand piece **200** includes an axially stepped collar **214** that is spaced rearwardly and serves an abutment surface for a spacer ring **290** of the hand piece retaining assembly **250**. The inner surface **201** of the hand piece **200** defines the four ribs **216**, as previously described, which permit the hand piece **200** to be oriented in any desired rotational position with respect to the gearbox housing **113**. A slotted radial opening **220** in the front face **212** of the hand piece **200** receives an optional actuation lever (not shown). The optional actuation lever, if used, allows the operator to actuate the power operated rotary knife **100** by pivoting the lever toward the gripping surface **204** thereby engaging the drive mechanism **600** to rotatably drive the rotary knife blade **300**.

The hand piece retaining assembly **250**, best seen in FIGS. **2** and **2**B, releasably secures the hand piece **200** to the gearbox housing **113**. The hand piece retaining assembly **250** includes the elongated central core **252** which extends through the central opening **202** of the hand piece **200**. The elongated core **252** threads into the threaded opening **149** (FIG. **48**) at the proximal or rearward end **122** of the gearbox housing **113** to secure the hand piece **200** to the gearbox housing **113**.

The hand piece retaining assembly **250** also includes the spacer ring **290** (FIG. **2**B). When the hand piece **200** is being secured to the gearbox housing **113**, the spacer ring **290** is positioned on the second cylindrical portion **147** (FIG. **48**) of the outer surface **146** of the cylindrical rearward section **116** of the gearbox housing **113**. The spacer ring **290** is positioned to abut the stepped shoulder **147***a* defined between the larger second portion **147** of the outer surface **146** of the cylindrical rearward portion **116** and the inverted U-shaped forward section **118** of the gearbox housing **113**. When the hand piece **200** is secured to the gearbox housing **113** by the elongated central core **252**, the spacer ring **290** is sandwiched between the hand piece **200** and the stepped shoulder **147***a* of the gearbox housing **113**.

As can best be seen in FIGS. **2**B and **8**, the elongated central core **252** of the hand piece retaining assembly **250** includes an inner surface **254** and an outer surface **256** extending between a distal or forward reduced diameter end portion **264** and the enlarged proximal or rearward end portion **260**. The inner surface **254** of the elongated central core **252** defines a throughbore **258** extending along the longitudinal axis LA of the handle assembly **110**. The elongated central core **252** also includes a threaded portion **262** on the outer surface **256** at the forward reduced diameter end portion **264**. The outer surface **256** of the elongated core **252** includes a radially outwardly stepped shoulder **265**.

When the elongated central core **252** is inserted through the central throughbore **202** and the threaded portion **262** of the core **252** is threaded into the threaded opening **149** of the gearbox housing **113**, the hand piece **200** is secured to the gearbox housing **113**. Specifically, the hand piece **200** is prevented from moving in the forward axial direction FW along the handle assembly longitudinal axis LA by the spacer ring **290**. The rear surface **292** of the spacer ring **290** acts as a stop for the axially stepped collar **214** of the distal end portion **210** of the hand piece **200** to prevent movement of the hand piece **200** in the forward direction FW. The hand piece **200** is prevented by moving in the rearward axial direction RW along the handle assembly longitudinal axis LA by the radially outwardly stepped shoulder **265** of the elongated central core **252**.

As can be seen in FIG. **8**, the stepped shoulder **265** of the elongated central core **252** bears against a corresponding inwardly stepped shoulder **218** of the hand piece **200** to prevent movement of the hand piece **200** in the rearward direction RW. As mentioned previously, the spacer ring **290** may be replaced by an optional operator thumb support. Additionally, a strap attachment bracket (not shown) may be disposed between the spacer ring **290** and the gearbox housing **113**. The strap attachment bracket, if used, provides an attachment point for an optional operator wrist strap (not shown).

Drive Shaft Latching Assembly **275**

The elongated central core **252** of the hand piece retaining assembly **250** includes the enlarged rearward or proximal end portion **260**. The enlarged end portion **260** supports a drive shaft latching assembly **275** which engages a first coupling **710** (FIGS. **1** and **53**) of an outer sheath **704** of the shaft drive assembly **700** to secure the outer sheath **704** of the shaft drive assembly **700** to the handle assembly **110** and thereby ensures operative engagement of a first male fitting **714** of the inner drive shaft **702** within the female socket **622** of the pinion gear input shaft **612**. The inner surface **254** of the elongated central core **252** also includes an inwardly stepped shoulder **266** (FIG. **8**) that provides a stop for a distal portion **711** of the first coupling **710** of the shaft drive assembly **700**.

As is best seen in FIG. 2B, the enlarged rearward end portion **260** of the elongated central core **252** of the hand piece retaining assembly **250** defines a generally U-shaped slot **268** that extends partially through the end portion **260** in a direction orthogonal to the longitudinal axis LA of the handle assembly **110**. The rearward end portion **260** also defines a central opening **270** (FIG. **8**) that is aligned with and part of the throughbore **258** of the elongated central core **252**. The central opening **270** ends at the inwardly stepped shoulder **266**. An end wall **272** of the rearward end portion **260** of the elongated central core **252** includes a peripheral cut-out **274**. The peripheral cut-out **274** is best seen in FIGS. **2**, 2B and **6**.

Disposed in the U-shaped slot **268** of the elongated central core **252** is the drive shaft latching assembly **275** (best seen in schematic exploded view in FIG. 2B) that releasably latches or couples the shaft drive assembly **700** to the handle assembly **110**. The drive shaft latching assembly **275** includes a flat latch **276** and a pair of biasing springs **278** inserted in the slot **268**. The flat latch **276** of the drive shaft latching assembly **275** includes a central opening **280** that is substantially equal to the size of the opening **270** of the enlarged end portion **260** of the elongated central core **252**.

The latch **276** is movable between two positions in a direction orthogonal to the longitudinal axis LA of the handle assembly **110**: 1) a first, locking position wherein the opening **280** of the latch **276** is offset from the opening **270** defined by the enlarged end portion **260** of the elongated central core **252**; and 2) a second release position wherein the opening **280** of the latch **276** is aligned with the opening **270** defined by the enlarged end portion **260** of the elongated central core **252**. The biasing springs **278**, which are trapped between peripheral recesses **281** in a bottom portion **282** of the latch **276** and the enlarged end portion **260** of the elongated central core **252**, bias the latch **276** to the first, locking position.

When the latch **276** is in the first, locking position a lower portion **286** of the latch **276** adjacent the latch opening **280** extends into the opening **270** of the enlarged end portion **260** of the core **252**. This can be seen schematically, for example in FIG. **6**. Movement of the latch **276** with respect to the enlarged end portion **260** is limited by the engagement of a holding pin **284** extending through a radially extending channel **283** formed in the latch **276**. The holding pin **284** bridges the U-shaped slot **268** of the enlarged end portion **260** and extends through the channel **283**. The channel **283** constrains and limits an extent of the radial movement of the latch **276** with respect to the enlarged end portion **260** of the elongated central core **252**.

Drive Mechanism **600**

As can best be seen in the schematic depiction of FIG. **53**, the knife blade **300** is rotatably driven in the blade housing **400** by the drive mechanism **600**. Within the power operated rotary knife **100**, the drive mechanism **600** includes the gearbox **602** supported by the gearbox housing **113**. The gearbox **602**, in turn, is driven by the flexible shaft drive assembly **700** and the drive motor **800** that are operatively coupled to the gearbox **602**. The flexible shaft drive assembly **700** is coupled to the handle assembly **110** by the drive shaft latching assembly **275**. A portion of the flexible shaft drive assembly **700** extends through the elongated central core **252** of the hand piece retaining assembly **250** and engages the pinion gear **610** to rotate the pinion gear about its axis of rotation PGR and thereby rotate the rotary knife blade **300** about its axis of rotation R.

As can best be seen in FIGS. **1** and **53**, the drive mechanism **600** includes the flexible shaft drive assembly **700** and the drive motor **800**. The shaft drive assembly **700** includes an inner drive shaft **702** and an outer sheath **704**, the inner drive shaft **702** being rotatable with respect to the outer sheath **704**. Affixed to one end **706** of the outer sheath **704** is the first coupling **710** that is adapted to be releasably secured to the enlarged rearward end portion **260** of the elongated central core **252** of the hand piece retaining assembly **250**. Affixed to an opposite end **708** of the outer sheath **704** is a second coupling **712** that is adapted to be releasably secured to a mating coupling **802** of the drive motor **800**.

When the first coupling **710** of the shaft drive assembly **700** is affixed to the hand piece **200**, the first male drive fitting **714** disposed at one end **716** of the inner drive shaft **702** engages the female socket or fitting **622** of the pinion gear input shaft **612** to rotate the pinion gear **610** about the pinion gear axis of rotation PGR. The rotation of the pinion gear **610** rotates the drive gear **650** which, in turn, rotates the rotary knife blade **300** about it axis of rotation R. When the second coupling **712** of the shaft drive assembly **700** is received by and affixed to the drive motor coupling **802**, a second drive fitting **718** disposed at an opposite end **720** of the inner drive shaft **702** engages a mating socket or fitting **804** (shown in dashed line in FIG. **53**) of the drive motor **800**. Engagement of the second drive fitting **718** of the inner drive shaft **702** and the drive motor fitting **804** provides for rotation of the inner drive shaft **702** by the drive motor **800**.

In the first, locking position of the latch **276** of the drive shaft latching assembly **275**, the lower portion **286** of the latch **276** extending into the opening **270** of the enlarged end portion **260** of the elongated central core **252** engages the first coupling **710** of the shaft drive assembly **700** to secure the shaft drive assembly **700** to the handle assembly **110** and insure the mating engagement of the first male drive coupling **714** of the drive shaft **702** to the female socket or fitting **622** of the pinion gear input shaft **612**. In the second, release position, the latch **276** is moved radially such that the opening **280** of the latch **276** is aligned with and coextensive with the opening **270** of the enlarged end portion **260** of the elongated central core **252** thus allowing for removal of the first coupling **710** of the shaft drive assembly **700** from the hand piece **200**.

The drive motor **800** provides the motive power for rotating the knife blade **300** with respect the blade housing **400** about the axis of rotation R via a drive transmission that includes the inner drive shaft **702** of the drive shaft assembly **700** and the gear train **604** of the gear box **602**. The drive motor **800** may be an electric motor or a pneumatic motor.

Alternately, the shaft drive assembly **700** may be eliminated and the gear train **604** of the gearbox **602** may be directly driven by an air/pneumatic motor or an electric motor disposed in the throughbore **258** of the elongated central core **252** of the hand piece retaining assembly **250** or in the throughbore **202** of the hand piece **200**, if a different hand piece retaining structure is used. A suitable air/pneumatic motor sized to fit within a hand piece of a power operated rotary knife is disclosed in U.S. non-provisional patent application Ser. No. 13/073,207, filed Mar. 28, 2011, entitled "Power Operated Rotary Knife With Disposable Blade Support Assembly", inventors Jeffrey Alan Whited, David Curtis Ross, Dennis R. Seguin, Jr., and Geoffrey D. Rapp. Non-provisional patent application Ser. No. 13/073,207 is incorporated herein in its entirety by reference.

Securing Shaft Drive Assembly **700** to Handle Assembly **110**

To secure the shaft drive assembly **700** to the hand piece **200**, the operator axially aligns the first coupling **710** of the drive shaft assembly **700** along the longitudinal axis LA of the handle assembly **110** adjacent the opening **270** defined by the enlarged end portion **260** of the elongated central core **252** of the hand piece retaining assembly **250**. The operator positions his or her thumb on the portion **288** of the latch **276** accessible through the peripheral cut-out **274** of the enlarged end portion **260** and slides the latch **276** radially inwardly to the second, release position. When the latch **276** is in the release position, the operator moves a forward portion **711** (FIG. **53**) of the first coupling **710** into the throughbore **258** of the elongated central core **252**.

After the forward portion **711** of the first coupling **710** is a received in the elongated central core **252** of the hand piece retaining assembly **250**, the operator then releases the latch **276** and continues to move the first coupling **710** further into the throughbore **258** of the central core **252** until the latch **276** (which is biased radially outwardly by the biasing springs **278**) snap fits into a radial securement groove **722** formed in an outer surface of the first coupling **710** of the shaft drive assembly **700**. When the latch **276** extends into the securement groove **722** of the first coupling **710**, the first coupling **710** is secured to the handle assembly elongated central core **252** and the first male drive fitting **714** of the inner drive shaft **702** is in operative engagement with the female socket or fitting **622** of the pinion gear input shaft **612**.

To release the shaft drive assembly **700** from the handle assembly elongated central core **252**, the operator positions his or her thumb on the portion **288** of the latch **276** accessible through the peripheral cut-out **274** of the enlarged end portion **260** of the elongated central core **252** and slides the latch **276** radially inwardly to the second, release position. This action disengages the latch **276** from the securement groove **722** of the first coupling **710** of the drive shaft assembly **700**. At the same time, the operator moves the first coupling **710** in the axial rearward direction RW out of the throughbore **258** of the elongated central core **252** and away from the handle assembly **110**. This will result in the first male drive fitting **714** of the drive shaft **702** being disengaged from the female fitting **622** of the pinion gear input shaft **612**.

Rotary Knife Blade Styles

As previously mentioned, depending on the cutting or trimming task to be performed, different sizes and styles of rotary knife blades may be utilized in the power operated rotary knife **100** of the present disclosure. Also, as previously mentioned, rotary knife blades in various diameters are typically offered ranging in size from around 1.2 inches in diameter to over 7 inches in diameter. Selection of a blade diameter will depend on the task or tasks being performed. Additionally, different styles or configurations of rotary knife blades are also offered. For example, the style of the rotary knife blade **300** schematically depicted in FIGS. **1-53** and discussed above is sometimes referred to as a "flat blade" style rotary knife blade. The term "flat" refers to the profile of the blade section **304** and, in particular, to a cutting angle CA (FIG. **24**) of the blade section **304** with respect to a plane CEP that is congruent with a cutting edge **350** of the blade **300**. The angle CA of the blade section **304** with respect to the cutting edge plane CEP is relatively large. As can be seen in FIG. **24**, the cutting angle CA, that is, the angle between the blade section **304** and the plane CEP, as measured with respect to the blade section inner wall **354** is an obtuse angle, greater than 90°. This large, obtuse cutting angle CA is referred to as a "shallow" blade cutting profile. As can be seen in FIG. **55**, the inner wall **360** is generally smooth, frustoconical shape. As the product P is being trimmed or cut by the flat blade **300**, the cut material layer CL1 moves easily along the inner wall **360** of the flat blade **300**. The flat blade **300** is particularly useful for trimming thicker layers of material from a product, e.g., trimming a thicker layer of fat or meat tissue from a piece of meat, as the power operated rotary knife **100** is moved over the product in a sweeping motion. This is true because even thicker layers of cut or trimmed material will flow with minimal drag or friction over the inner wall **360** of the flat blade **300**.

Another blade profile is shown in the "hook blade" style rotary knife blade which is schematically depicted at **1000** in FIG. **56**. Here the cutting angle CA with respect to the plane CEP defined by the cutting edge **1050**, may be about the same or slightly larger or smaller than the cutting angle CA of the rotary knife blade **300** (see FIG. **24**). However, the inner profile of the hook blade **1000** is less planar and more V-shaped that the inner profile of the flat blade **300**. That is, as the inner surface of the blade curves radially inwardly as one moves from the blade section **1004** to the body section **1002**. This inward curvature of the inner surface of the hook blade **1000** results in a less smooth and more curved path of travel for cut or trimmed material, as compared with the flat blade **300**. Thus, the hook blade **1000** is particularly useful for trimming relatively thin layers of material from a product, for example, trimming a thin layer of fat or meat tissue from a relatively planar, large piece of meat, as the power operated rotary knife **100** is moved over the product in a sweeping motion. For trimming thicker layers of material from a product, the hook blade **1000** would not be as efficient because the curved path of travel of the cut or trimmed material layer would result in the power operated rotary knife **100** experiencing more drag and resistance during cutting or trimming. Thus, more effort would be required by the operator to move and manipulate the power operated rotary knife **100** to make the desired cuts or trims.

As can also be seen, the shape of the rotary knife blade body **1002** is also different than the body **302** of the flat rotary knife blade **300**. Accordingly, the shape of a blade support section **1450** of a blade housing **1400** is also modified accordingly from the shape of the blade support section **450** of the blade housing **400** when used in the power operated rotary knife **100**. That is, the shape of a particular rotary knife blade selected to be used in the power operated rotary knife **100** will sometimes require modification of the associated blade housing for the power operated rotary knife **100**. However, the blade-blade housing bearing structure **500** and gear train **604**, as discussed above, are utilized to support and drive the blade **1000**. Additionally, as discussed above, the driven gear **1030** of the knife blade **1000** is spaced axially below the bearing race **1020**.

A more aggressive blade profile is shown in the "straight blade" style rotary knife blade which is schematically depicted at **1500** in FIG. **57**. The cutting angle CA is smaller than the cutting angles of the rotary knife blades **300** and **1000**. Indeed, the cutting angle CA of the knife blade **1500** is an acute angle of less than 90° with respect to the plane CEP defined by the cutting edge **1550**. The cutting angle CA of the straight blade **1500** is very "steep" and more aggressive than the flat blade **300** or the hook blade **1000**. A straight blade is particularly useful when make deep or plunge cuts into a product, i.e., making a deep cut into a meat product for the purpose of removing connective tissue/gristle adjacent a bone.

As can also be seen, the shape of the knife blade body **1502** is also different than the body **302** of the flat rotary knife blade **300**. Accordingly, the shape of a blade support section **1950** of a blade housing **1900** is also modified accordingly from the shape of the blade support section **450** of the blade housing **400** when used in the power operated rotary knife **100**. However, the blade-blade housing bearing structure **500** and gear train **604**, as discussed above, are utilized to support and drive the blade **1500**. Additionally, as discussed above, the driven gear **1530** of the knife blade **1500** is spaced axially below the bearing race **1520**.

Other rotary knife blades styles, configurations, and sizes exist and may also be used with the power operated rotary knife **100**. The blade-blade housing structure **500** of the present disclosure and the other features, characteristics and attributes, as described above, of the power operated rotary knife **100** may be used with a variety of rotary knife blades styles, configurations, and sizes and corresponding blade housings. The examples recited above are typical blade styles (flat, hook, and straight), but numerous other blade styles and combination of blade styles may be utilized, with an appropriate blade housing, in the power operated rotary knife **100** of the present disclosure, as would be understood by one of skill in the art. It is the intent of the present application to cover all such rotary knife blade styles and sizes, together with the corresponding blade housings, that may be used in the power operated rotary knife **100**.

Second Exemplary Embodiment

Two-Piece Rotary Knife Blade **2300**

In first exemplary embodiment of the power operated rotary knife **100**, the annular knife blade **300** was integral, that is, the body **302** and the blade section **304** of the knife blade **300** comprised a single unitary structure. When in use, the rotary knife blade **300** typically has to be sharpened after 5-10 hours of use. The length of time between sharpenings will depend on a number of variables including the application, that is, the nature of the product being cut or trimmed, the skill of the operator in using the rotary knife, for example, a skilled operator will avoid gouging the blade into bones of the carcass when trimming or cutting meat or fat from a carcass, and the care and maintenance provided to the power operated rotary knife, including the rotary knife blade. Each sharpening of the knife blade **300** removes material from the blade section **304** thereby decreasing an extent of the blade.

While the number of times that the knife blade **300** may be sharpened will vary depending upon the cutting/trimming application, the skill of the operator, the maintenance/cleaning regimen of the power operated rotary knife, the skill of the person performing the sharpening operation, etc., in most cases the blade section **304** will reach the end of its useful life while the body is still suitable for use. Generally, repeated sharpenings of the blade section **304** will decrease an extent of the blade section to a point where the knife blade **300** is no longer suitable to be used in the power operated rotary knife **100**. For example, if an axial extent of the blade section **304** is reduced by repeated sharpenings to a point the blade edge **350** is axially even with or axially above the bottom surface **458** of the blade support section **450** of the blade housing **400**, the rotary knife blade **300** will no longer be suitable for use. When repeated sharpening of the knife blade **300** have reduced the blade section **304** to a point of being worn out, the blade body **302**, including the driven gear **328** defined by the body **302**, will typically still be suitable for use and, in fact, the blade body **302** have many hours of useful life remaining. Nevertheless, because the knife blade **300** is a unitary structure, the entire blade **300** must be discarded upon wearing out of the blade section **304** even though the body **302** may have many hours of useful life remaining.

In an alternate exemplary embodiment of the present disclosure and as shown generally in FIGS. **59-73**, an annular, rotary knife blade **2300** comprises a two-part or two-piece structure including a carrier portion **2302** and a blade portion **2350**. In one exemplary embodiment, both the carrier portion **2302** and the blade portion **2350** are one-piece, continuous annular pieces. The two-piece knife blade **2300** is schematically shown as a straight style blade, but the concepts discussed herein regarding a two-piece blade are equally applicable to flat and hook style rotary knife blades.

The knife blade **2300** extends axially between an upper end **2300***a*, defined by an upper wall **2365** of the blade portion **2350**, and a lower end **2300***b*, defined by a lower or distal end **2366** of the blade portion **2350**. The lower end **2366** of the blade portion **2350** defines a cutting edge **2368** of the knife **2300**. The knife blade **2300** is adapted for use in a power operated rotary knife, such as the power operated rotary knife **100**, although it should be appreciated that structural changes to other, mating components of the power operated rotary knife **100** (e.g., the blade housing **400**) will be required to accommodate the specific configuration of the two-part knife blade **2300**. As used in a power operated rotary knife **100**, the two-part rotary knife blade **2300** will rotate about a central axis or an axis of rotation R' (FIG. **59**) of the knife blade **2300** (similar to the axis of rotation R of the rotary knife blade **300**). The two-part knife blade **2300** includes a bearing race **2320** that defines a rotational plane RP' (FIG. **63**) of the knife blade **2300** (similar to the rotational plane RP of the rotary knife blade **300**).

The blade portion **2350** is releasably secured or affixed to the carrier portion **2302**. The carrier portion **2302**, which includes a driven gear which may be formed, for example, in a gear bobbing machining operation, is more expensive to fabricate than the blade portion **2350**. In one exemplary embodiment, the carrier portion **2302** is fabricated of a hardenable grade of alloy steel or a hardenable grade of stainless steel, or other material or materials known to have comparable properties and may be formed/shaped by machining, forming, casting, forging, extrusion, metal injection molding, and/or electrical discharge machining or another suitable process or combination of processes. In one exemplary embodiment, the blade portion **2350** is fabricated of an alloy steel or stainless steel, or other material or materials known to have comparable properties and may be advantageously formed in a steel stamping operation or other suitable process or combination of processes.

The carrier portion **2302** will have a longer useful life than the less expensive blade portion **2350**. Thus, when the blade portion **2350** is worn out and the carrier portion **2302** still has useful life remaining, the worn out blade portion **2350** is unlocked and removed from the carrier portion **2302** and a new blade portion is installed or affixed to the carrier portion **2302**. In this way, multiple, relatively inexpensive, blade sections **2350** may be utilized for a given carrier portion **2302** thereby providing a lower overall total cost for rotary knife blades over the expected life of the carrier portion **2302**, as compared to using and discarding single piece rotary knife blades.

As can best be seen in FIGS. **59-63**, which show the axial alignment of the blade portion **2350** and the carrier portion **2302**, the carrier portion **2302** carries or supports the blade portion **2350** in a nested relationship. As can be seen in FIG. **63**, a central portion **2364** of the blade portion **2350** is disposed within the axially shorter carrier portion **2302**. The blade portion **2350** is releasably secured to the carrier portion **2302** via a twist-and-lock attachment structure **2370** (FIGS. **62-65**) that provides a secure attachment between the blade portion **2350** and the carrier portion **2302**. In addition to the lower overall total blade cost discussed above, the nesting relationship of the central portion **2364** of the blade portion **2350** within the carrier portion **2302** and the attachment structure **2370** provides additional advantages. The attachment structure **2370** configuration is such that rotation of the rotary blade **2300** in the blade housing **400** tends to increase a tightness of the attachment between the blade portion **2350** and the carrier portion **2302**. Viewed from the central axis of rotation R from above the knife, the drive mechanism **700** of the power operated rotary knife **100** is configured to rotate the knife blade **2300** in a counterclockwise rotational direction (shown as CCW in FIGS. **59** and **62**). The attachment structure **2370** is configured such that rotation of the rotary knife blade **2300** in the counterclockwise rotational direction CCW direction tends to tighten the attachment structure **2370** thereby tightening and further securing the attachment between blade portion **2350** and the carrier portion **2302**.

Moreover, because of the nested relationship between the blade portion **2350** and the carrier portion **2302**, as is best seen in FIG. **63**, when the knife blade **2300** is in an assembled state **2399**, an area of contact between the facing surfaces of the blade portion **2350** and the carrier portion **2302** is large. The assembled state **2399** of the knife blade **2300** being schematically depicted FIGS. **59-63** and **66**, while an unassembled state **2398** of the knife blade **2300** is schematically depicted in FIGS. **67-69**. When in the assembled state **2399**, the nested configuration and large surface area of contact between the blade portion **2350** and the carrier portion **2302** provides strength, stability and durability to the assembled knife blade **2300**. In the overlap region **2364** of the blade portion **2350** and the carrier portion **2302**, the respective walls of the blade and carrier portions **2350**, **2302** are radially aligned thereby providing a double wall for strength and rigidity of the knife blade **2300**.

Carrier Portion **2302**

As is best seen in FIGS. **61**, **63** and **69**, the carrier portion **2302** includes an inner wall **2304** and a radially spaced apart outer wall **2306**, a first end or top surface or upper wall **2308** and an axially spaced apart bottom surface or second end or lower wall **2310**. The inner and outer walls **2304**, **2306** are radially spaced apart by a central wall **2316** (FIG. **63**). The carrier portion **2302**, when viewed axially or vertically, includes an upper region **2311** and a lower region **2312** separated by a knee or transition region **2313** between the upper region **2311** and the lower region **2312**. In the upper region **2311** of the carrier portion **2302**, a generally cylindrical surface **2314** is defined by the inner wall **2304**, while in the lower region **2312** of the carrier portion **2302**, a generally frustoconical surface **2315** is defined by the inner wall **2304**. The cylindrical surface **2314** is substantially centered about and coaxial with the axis of rotation R' of the knife blade **2300**. The frustoconical surface **2315** converges in an upward direction UP' (FIG. **69**), that is, the frustoconical surface **2315** converges proceeding in a direction toward the upper surface **2308** of the carrier portion **2302** and is generally coaxial with the axis of rotation R' of the knife blade **2300**.

A portion of the outer wall **2306** that is axially spaced from the top surface **2308** of the carrier portion **2302** and also axially spaced from the upper end **2300*a*** of the rotary knife blade **2300** defines a bearing surface **2319** for the blade **2300**. In one exemplary embodiment, the bearing surface **2319** defines the bearing race **2320** that projects radially inwardly into a generally cylindrical portion **2340** of the outer wall **2306** of the upper region **2311** of the carrier portion **2302**. The bearing race **2320**, in one exemplary embodiment, includes an arcuate bearing surface **2322** in a central portion **2324** of the bearing race **2320**. The bearing race **2320** of the carrier portion **2302** is configured and functions similarly to the bearing race **320** of the rotary knife blade **300**, as previously described. That is, the bearing race **2320** of the knife blade **2300** is part of the rotary knife bearing assembly **552** of the power operated rotary knife **100**.

Axially spaced in a downward direction DW' (FIG. **69**) from the bearing surface **2319** is an outwardly stepped portion **2331** of the outer wall **2306** of the carrier portion **2302**. The stepped portion **2331** of the outer wall **2306** defines a driven gear **2328** of the knife blade **2300**. In one exemplary embodiment, the driven gear **2328** defines a spur gear comprising a set or a plurality of radially extending, involute gear teeth **2330**, like the plurality of gear teeth **330** of the knife blade **300**. A radial outer surface **2330*a*** of the plurality of gear teeth **2330** define a cylindrical outer periphery **2336** this is shown schematically in dashed line in FIG. **61**. In FIG. **61**, for clarity, the cylindrical outer periphery **2336** is shown positioned above its true location which would be along the radial outer surface **2330*a*** of the plurality of gear teeth **2330**. A generally horizontally or radially extending step or shoulder **2334** extends from the lower terminus of the driven gear **2328**. The shoulder **2334** inhibits the ingress of pieces of bone, fat, gristle and other debris into the driven gear **2328** and the bearing race **2320** during cutting and trimming operations with the power operated rotary knife **100** using the rotary knife blade **2300**. As can be seen, the driven gear **2328** is axially spaced from the bottom surface **2310** of the carrier portion **2302**.

As can best be seen in FIG. **68**, which shows the carrier portion **2302** and the blade portion **2350** in the unassembled state **2398**, and FIG. **70** which shows a schematic bottom plan view of the carrier portion **2302**, inner wall **2304** in the lower region **2312** of the carrier portion **2302** includes four cavities or sockets **2374**. The sockets **2374** define recesses in the inner wall **2304** of the carrier portion and extend from a bottom wall **2310*a*** defining the bottom surface **2310** of the carrier portion **2302** radially into the inner wall **2304** of the carrier portion **2302**. The sockets **2374** are part of the twist-and-lock attachment structure **2370** of the knife blade **2300**. The twist-and-lock attachment structure **2370** releasably secures the blade portion **2350** to the carrier portion **2302** in a nested configuration (FIG. **63**). The recesses defined by the sockets **2374** have a longitudinal extent, as measured along the knee **2313** of the carrier portion **2302**, that is, generally parallel to the extent of the knee **2313** and generally parallel to the top surface **2308** of the carrier portion **2302**. In one exemplary embodiment, the inner wall **2304** in the lower region **2312** of the carrier portion **2302** includes four sockets **2374*a***, **2374*b***, **2374*c***, **2374*d***, spaced peripherally apart at 90° increments. The four sockets **2374** each include a first, wider opening region **2376**, a second, tapering region **2378** and a third, narrow locking region **2380**.

The first, wider opening region **2376** is defined by a lower surface **2376*b*** and an axially spaced upper surface **2376*a***. The lower surface **2376*b*** defines a projection receiving opening **2376*c*** of the socket **2374**. The projection receiving opening **2376*c*** forms a portion of the bottom wall **2310*a*** of the carrier portion **2302**. The upper surface **2376*a*** extends substantially parallel to the knee **2313** of the inner wall **2304** of the carrier portion **2302**. A spacing between the lower surface **2376*b*** and the upper surface **2376*a***, as measured along the inner wall **2304**, is a maximum in the first, wider opening region **2376**.

The second, tapering region **2378** is defined by a lower surface **2378***b* and an axially spaced upper surface **2378***a* that extends substantially parallel to the knee **2313** of the inner wall **2304** of the carrier portion **2302**. In the second, tapering region **2378**, the spacing between the lower surface **2378***b* and the upper surface **2378***a*, as measured along the inner wall **2304**, tapers and narrows proceeding from the first, wider opening region **2376** toward the third, locking region **2380**. Finally, the third, locking region **2380** is defined by a lower surface **2380***b* and an axially spaced upper surface **2380***a* that extends substantially parallel to the knee **2313** of the inner wall **2304** of the carrier portion **2302**. In the third, locking region **2380**, the spacing between the lower surface **2380***b* and the upper surface **2380***a*, as measured along the inner wall **2304**, is a minimum for the socket **2374**.

The respective lower surfaces **2378***b*, **2380***b* of the tapering and locking regions **2378**, **2380** of the socket **2374**, define a caroming surface **2379**. The spacing between the upper and lower surfaces **2376***a*, **2376***b*, as measured along the inner wall **2304** of the carrier portion **2302** is a maximum in the first wider opening region **2376** of the socket **2374**. In the second, tapering region **2378** and the third, locking region **2380**, the spacing between the upper and lower surfaces, **2378***a*, **2378***b* and **2380***a*, **2380***b* generally tapers or narrows, as measured along the inner wall **2304** of the carrier portion **2302**, because the camming surface **2379** proceeds in a direction toward the respective upper surfaces **2378***a*, **2380***a* of the second, tapering region **2378** and the third, locking region **2380**. Thus, the camming surface **2379** extends from the projection receiving opening **2376***c* of the first, wider opening region **2376** to a terminal end **2381** of the socket **2374** in the third, locking region **2380**.

It should be understood that the plurality of sockets **2374**, in the exemplary embodiment of the two-piece rotary knife blade **2300** schematically shown in FIGS. **59-73**, are configured as indentations or cavities extending into the inner wall **2304** of the carrier portion **2302**, but not extending all the way through to the outer wall **2306** of the carrier portion **2302**. However, it should be appreciated that the present disclosure contemplates that the configuration of the carrier portion **2302** and the blade portion **2350** may be reversed, that is, the carrier portion **2302** may include the plurality of projections and the blade portion **2350** may include the mating plurality of sockets. In the knife blade **2300**, the sockets **2374** of the carrier portion **2302** are configured as indentations or cavities that extend from the inner wall **2304** into the central wall **2316** of the carrier portion **2302**. However, in other exemplary embodiments contemplated by the present disclosure, the plurality of sockets may comprise openings that pass completely through from the inner to the outer wall of either the carrier portion or the blade portion, depending on which piece is configured to include the plurality of sockets. For example, in the two-piece rotary knife blade **4300**, shown schematically in FIGS. **82-90**, a blade portion **4350** includes a plurality of sockets **4374**. Each of the plurality of sockets **4374** of the blade portion **4350** extends from an inner wall **4352** through an outer wall **4354** of the blade portion **4350**, that is, the sockets **4374** extend completely through a central wall **4356** and the inner and outer walls **4352**, **4354** of the blade portion **4350**.

When the blade portion **2350** is moved and relative to the carrier portion **2302** such that a mating projection **2372** of the blade portion **2350** enters the projection receiving opening **2376***c* of the socket **2474** and the blade portion is twisted or rotated relative to the carrier portion **2302** such that the projection **2372** moves from the first, wider opening region **2376** (shown schematically in FIG. **64**) through the second, tapering region **2378** (FIG. **65**) into the third, locking region **2380** (FIG. **66**), the camming surface **2379** of the sockets **2374** contacts and guides the projections **2372** along a locking path of travel LPT (FIG. **70**) such that: a) the blade portion **2350** is axially urged or moved in an upward direction UP' (FIGS. **63** and **69**) against the carrier portion **2302**; b) the blade portion **2350** is secured or attached to the carrier portion **2302**; and c) the knife blade **2300** is transformed from the unassembled condition **2398** to the assembled condition **2399**.

Blade Portion **2350**

As is best seen in FIGS. **69** and **71-73**, the blade portion **2350** includes an inner wall **2352** and a radially spaced apart outer wall **2354**. The blade portion further includes a first end or upper wall **2365** and an axially spaced apart second or lower end **2366**. As can best be seen in FIG. **63**, the upper wall **2365** of the blade portion **2350** defines the upper end **2300***a* of the knife blade, while the lower end **2366** of the blade portion **2350** defines the lower end **2300***b* of the knife blade **2300**. The blade portion **2350** includes an upper, generally cylindrical region **2355***a* and a lower, generally frustoconical region **2355***b* having a knee or transition region **2355***c* between the upper region **2355***a* and the lower region **2355***b*. As can be seen in FIG. **63**, the inner and outer walls **2352**, **2354** are substantially parallel and the knee **2355***c* extends horizontally or radially across between the inner and outer walls **2352**, **2354**. The inner and outer walls **2352**, **2354** are separated radially by a central wall **2356** which defines a thickness of the blade portion **2350**.

The inner wall **2352** defines a generally cylindrical surface **2360** in the upper region **2355***a* and a generally frustoconical surface **2361** in the lower region **2355***b*. The cylindrical surface **2360** is substantially centered about and coaxial with the axis of rotation R' of the knife blade **2300** (similar to the axis of rotation R of the rotary knife blade **300**). The frustoconical surface **2361** converges in the upward direction UP' (FIGS. **63** and **69**) and is generally coaxial with the axis of rotation R' of the knife blade **2300**. The outer wall **2354** defines a generally cylindrical surface **2362** in the upper region **2355***a* and a generally frustoconical surface **2363** in the lower region **2355***b*. The cylindrical surface **2362** is substantially centered about and coaxial with the axis of rotation R' of the knife blade **2300**. The frustoconical surface **2363** converges in the upward direction UP' (FIG. **69**) and is generally coaxial with the axis of rotation R' of the knife blade **2300**. When the knife blade **2300** is in the assembled state **2399**, the blade portion **2350** and the carrier portion **2302** are in a nested relationship or configuration, that is, a portion of the cylindrical surface **2362** of the outer wall **2354** within the overlap region **2364** (FIG. **63**) of the blade portion **2350** confronts and snugly fits within the cylindrical surface **2314** of the inner wall **2304** of the carrier portion **2302**, a portion of the frustoconical surface **2363** of the outer wall **2354** within the overlap region **2364** of the blade portion **2350** confronts and snugly fits within the frustoconical surface **2315** of the inner wall **2304** of the carrier portion, and the knee **2355***c* in the region of the outer wall **2354** of the blade portion **2350** is confronts and is adjacent to the knee **2313** of the carrier portion **2302**. Thus, as a result of the nesting configuration, there is a large area or region of contact between facing surfaces of the inner wall **2304** of the carrier portion **2302** and the outer wall **2354** of the blade portion **2350**.

The lower or distal end **2366** of the blade portion **2350** defines the cutting edge **2368** of the blade portion **2350**. The lower end **2366** includes a bridging portion **2367** that bridges the inner and outer walls **2352**, **2354**. The blade cutting edge **2368** is defined at an intersection of the bridging portion **2367** and the inner wall **2352**.

As best seen in FIGS. **67** and **71-72**, the blade portion **2350** includes a plurality of projections **2372** which extend outwardly from frustoconical surface **2363** of the outer wall **2352**. Like the sockets **2374** of the carrier portion **2302**, the projections **2372** are part of the twist-and-lock attachment structure **2370** of the knife blade **2300**. In one exemplary embodiment, the number of projections is four, namely, projections **2372***a*, **2372***b*, **2372***c*, **2372***d*. The four projections **2372** are peripherally spaced about the outer wall **2354** at 90° increments. In one exemplary embodiment, the projections **2372** are formed by stamping or punching completely through the blade wall **2356** (FIGS. **63** and **73**) of the blade portion **2350**. This approach leaves a cavity or opening **2373** (FIG. **73**) in the blade central wall **2356** where each of the projections **2372** is formed. As would be understood by those of skill in the art, other techniques may be utilized to suitably form the projections **2372**. As can best be seen in FIGS. **64** and **73**, each of the plurality of projections **2372** includes a generally planar end wall **2390**.

The projections **2372** extend radially outwardly from the frustoconical surface **2363** of the outer wall **2354** of the blade portion **2350** and, thus, an acute angle A (FIG. **73**) of the projections **2372** with respect to the axis of rotation R' of the knife blade **2300** has to be greater in magnitude than an acute angle B of the frustoconical surface **2363** of the outer wall **2354**. The angle B of the frustoconical surface **2363** will vary depending on the intended use and configuration of the knife blade. In one exemplary embodiment, wherein the two-piece rotary knife blade **2300** is a straight blade style rotary knife blade and is a small diameter rotary knife blade, the acute angle A of the four projections **2372** is approximately 60°+/−10° and the acute angle B of the frustoconical surface **2363** is approximately 21°+/−10°. Typically, a small diameter rotary knife blade would be a rotary knife blade having an inner diameter of approximately 3 inches or less. Each of the projections **2372** are sized to be received into the opening region **2376***c* of any one of the four sockets **2374** and when the blade portion **2350** is appropriately positioned and then rotated or twisted with respect to the carrier portion **2302**, the projections **2372** and, specifically, the end wall **2390** of the plurality of projections **2372**, each move along and bear against the camming surface **2379** of the sockets **2374** as the projections **2372** traverse along the path LPT from the first, wider opening region **2376** through the second, tapering region **2378** to the third, locking region **2380** to secure the blade portion **2350** to the carrier portion **2302**.

Twist-and-Lock Attachment Structure **2370**

As mentioned previously, the carrier portion **2302**, which may be machined from stainless steel or similar steel alloy, is more expensive to fabricate than the blade portion **2350**, which may be stamped from stainless steel or similar steel alloy. The carrier portion **2302** and the blade portion **2350** are releasably affixed via the twist-and-lock attachment structure **2370** which allows the blade portion **2350** to be securely affixed to the carrier portion **2302** such that the knife blade **2300** may be used in the power operated rotary knife **100**. The twist-and-lock attachment structure **2370** also allows the blade portion **2350** to be removed from the carrier portion **2302** when the blade portion **2350** reaches the end of its useful life such that it can be replaced by a new blade portion and the knife blade **2300** may continue to be used in the power operated rotary knife **100** though multiple replaced blade portions.

Advantageously, the attachment structure **2370** is configured such that, as the knife blade **2300** is driven for rotation in the blade housing **400**, the forces resulting from the rotation of the knife blade **2300** tend to tighten the attachment between the blade portion **2350** and the carrier portion **2302**. As mentioned previously, a direction of rotation of the knife blade **2300** in the rotary knife **100** is in a counterclockwise rotational direction CCW when viewed from the blade central axis R' axially above the upper end **2300***a* of the knife blade **2300**. To affix the blade portion **2350** to the carrier portion **2302**, a direction of rotation of the blade portion **2350** with respect to the carrier portion **2302** is in a clockwise rotational direction CW (FIG. **62**) when viewed from the blade central axis R' axially above the upper end **2300***a* of the blade **2300**.

The attachment structure **2370** includes the plurality of projections **2372** extending radially outwardly from the outer wall **2354** of the blade portion **2350** and the mating plurality of sockets **2374** formed in the inner wall **2304** of the carrier portion **2302**. The attachment structure **2370** provides for movement of the plurality of projections **2372** with respect to the plurality of sockets **2374** between a release position, where the blade portion **2350** is capable of being moved axially away from the carrier portion **2302** and the locking position, where the blade portion **2350** is secured to the carrier portion **2302**. In one exemplary embodiment, there are four projections **2372***a*, **2372***b*, **2372***c*, **2372***d* and four mating sockets **2374***a*, **2374***b*, **2374***c*, **2374***d*. Of course, it should be recognized that the number of projections and mating sockets may be greater or less than four.

As previously discussed, each socket **2374***a*, **2374***b*, **2374***c*, **2374***d* in the plurality of sockets **2374** includes three adjacent regions **2376**, **2378**, **2380** allowing for the twist-and-lock functionality of the attachment structure **2370**. Each socket, referred to generally as socket **2374**, includes the first, wider opening region **2376**, the second, tapering region **2378**, and the third, narrower locking region **2380**. The respective upper surfaces **2376***a*, **2378***a*, **2380***a* of the three regions **2376**, **2378**, **2380** are aligned and substantially parallel to the knee **2355***c* of the blade portion.

By contrast, the respective lower surfaces **2378***b*, **2380***b* of the tapering and locking regions **2378**, **2380**, define the camming surface **2379** which generally tapers toward the upper surfaces **2378***a*, **2380***a* thereby reducing the spacing between the respective upper and lower surfaces, as measured along the inner wall **2304** of the carrier portion **2302**, in moving from the first, opening region **2376** through the second, tapering region **2378** to the third, locking region **2380**. The camming surface **2379** extends from the projection receiving opening **2376***c* of the first, wider opening region **2376** to the terminal end **2381** of the socket **2374** in the third, locking region **2380**. Each of the sockets **2374** comprises a recess **2375** extending radially into the inner wall **2304** of the carrier portion **2302**, the recess **2374***e* having a longitudinal extent RLE (FIG. **70**) that is substantially parallel to the first and second ends **2308**, **2310** of the carrier portion **2302**.

To secure the blade portion **2350** to the carrier portion **2302**, the blade portion **2350** and the carrier portion **2302** are axially and rotationally aligned such that each projection **2372***a*, **2372***b*, **2372***c*, **2372***d* of the plurality of projections **2372** is received in a respective socket **2374***a*, **2374***b*, **2374***c*, **2374***d* of the plurality of sockets **2374**. Specifically, the carrier portion **2302** is positioned above the blade portion **2350**. The carrier portion **2302** is moved in the downward direction DW' (FIGS. **63** and **69**) with respect to the blade portion **2350**. The carrier portion **2302** is aligned and rotated with respect to the blade portion such that each projection **2372***a*, **2372***b*, **2372***c*, **2372***d* is received into the projection receiving opening region **2376***c* defined by the lower surface **2376***b* of the first, wider opening region **2376** of its respective mating socket **2374***a*, **2374***b*, **2374***c*, **2374***d*.

Next, after proper alignment, to secure the blade portion **2350** to the carrier portion **2302**, the blade portion **2350** is rotated with respect to the carrier portion **2302** in a clockwise direction of rotation CW (when viewed from above) to the locked position wherein the knife blade **2300** is in the assembled condition **2399**. As the blade portion **2350** is rotated with respect to the carrier portion **2302**, each of the projections **2372***a*, **2372***b*, **2372***c*, **2372***d* of the plurality of projections **2372** moves along the camming surface **2379** and along a locking path of travel LPT (FIG. **70**) within a respective socket **2374***a*, **2374***b*, **2374***c*, **2374***d* of the plurality of sockets **2374**. As a given projection **2372** moves along the locking path of travel LPT in a socket **2374** from the first, wider opening region **2376** to the third, narrow locking region **2380**, the projection **2372** is axially displaced by the camming surface **2379** (defined by the lower surfaces **2378***b*, **2380***b* of the tapering and locking regions **2378**, **2380**) such that the outer wall **2354** of the blade portion **2350** and the inner wall **2304** of the carrier portion **2302** are urged axially toward each other and the blade portion **2350** is secured to the carrier portion **2302**. FIGS. **64-66** schematically illustrate, in section view, movement of a representative projection **2372** within a socket **2374** along the locking path of travel LPT from the first, wider opening region **2376** (shown in FIG. **64**—unlocked position), to the second, tapering region **2378** (shown in FIG. **65**—partially locked position), to the third, locking region **2380** (shown in FIG. **66**—locked position—assembled condition). As can be seen in the progression of FIGS. **64-66**, as the twist and lock securement of the blade portion **2350** to the carrier portion **2304** occurs, the blade portion **2350** is urged axially to full engagement with the carrier portion **2304** in the nesting configuration depicted in FIG. **63**.

As can best be seen in FIGS. **65** and **66**, as the blade portion **2350** is rotated or twisted in the clockwise direction CW with respect to the carrier portion **2302**, when viewed from above, the generally planar end wall **2390** of each of the plurality of projections **2372** bears against and rides along the camming surface **2379** in the second, tapering region **2378** and third, locking region **2380** of the respective sockets **2374**. As the end wall **2390** of the projections **2374** rides along the camming surface **2379**, the blade portion **2350** is urged in the upward axial direction UP' (FIGS. **63** and **69**) into a nested configuration with the carrier portion **2302**, that is, the locked position or the assembled condition **2399**.

To release the blade portion **2350** from the carrier portion **2302**, that is, to move the knife blade **2300** from an assembled condition **2399** to a disassembled condition **2398**, the process is reversed. That is, the blade portion **2350** is rotated with respect to the carrier portion **2302** in the counterclockwise direction of rotation CCW (when viewed from above) to the release position. In moving from the locking position to the release position, each of the projections **2372***a*, **2372***b*, **2372***c*, **2372***d* of the plurality of projections **2372** moves along a release path of travel RPT (FIG. **70**) within a respective socket **2374***a*, **2374***b*, **2374***c*, **2374***d* of the plurality of sockets **2374** that is opposite to the locking path of travel LPT. As a given projection **2372** moves along the release path of travel RPT from the third, narrow locking region **2380** to the first, wider opening region **2376**, the projection **2372** tends to move along the camming surface **2379** of the socket **2374** such that the outer wall **2354** of the blade portion **2350** and the inner wall **2304** of the carrier portion **2302** tend to move away from each other. When each of the projections **2372***a*, **2372***b*, **2372***c*, **2372***d* of the plurality of projections **2372** are in the first, wider opening region **2376** of their respective sockets **2374***a*, **2374***b*, **2374***c*, **2374***d* of the plurality of sockets **2374**, the blade portion **2350** may be moved axially away from the carrier portion **2302** to thereby complete the release of the blade portion **2350** from the carrier portion **2302** and thereby achieve the disassembled condition.

Alternate Exemplary Embodiments

Two-Piece Rotary Knife Blades

In FIGS. **74-99**, three alternate exemplary embodiments of annular, rotary knife blades **3300** (FIGS. **74-81**), **4300** (FIGS. **82-90**), **5300** (FIGS. **91-99**) are schematically shown, each knife blade comprising a two-part or two-piece structure including a carrier portion and a blade portion. Each of the rotary knife blades **3300**, **4300**, **5300** includes a twist-and-lock attachment structure **3370**, **4370**, **5370** that releasably couples the carrier portion to the blade portion. The rotary knife blades **3300**, **4300**, **5300** are generally similar in structure and function to the two-piece rotary knife blade **2300** and the foregoing discussion and description of the two-piece rotary knife blade **2300** is incorporated with respect to the description of each of the following two-piece rotary knife blades **3300**, **4300**, **5300**.

The attachment structures **3370**, **4370**, **5370** of the respective two-piece rotary knife blades **3300**, **4300**, **5300** differ in structure from the attachment structure **2370** of the two-piece rotary knife blade **2300**. Accordingly, the following discussion of the rotary knife blades **3300**, **4300**, **5300** will focus on the respective attachment structures **3370**, **4370**, **5370**. Each of the rotary knife blades **3300**, **4300**, **5300** is configured to be used in a power operated rotary knife of the present disclosure, such as, for example, the power operated rotary knife **100**, although it should be appreciated that structural changes to other, mating components of the power operated rotary knife **100** (e.g., the blade housing **400**) will be required to accommodate the specific configuration, size and/or diameter of the two-piece knife blades **3300**, **4300**, **5300**. In one exemplary embodiment of the rotary knife blades **3300**, **4300**, **5300**, both the carrier portion and the blade portion are one-piece, continuous annular pieces. Each of the two-piece knife blades **3300**, **4300**, **5300** are schematically shown in FIGS. **74-99** as flat style rotary knife blades, but the concepts presented herein are equally applicable to hook and straight style rotary knife blades.

Two-Piece Rotary Knife Blade 3300

Turning to FIGS. **74-81**, the two-piece rotary knife blade **3300** includes the carrier portion **3302** and the blade portion **3350**. The rotary knife blade **3300** is schematically shown in assembled condition **3399** in FIGS. **74-76** and in unassembled condition **3398** in FIGS. **77** and **78**. The rotary knife blade **3300**, in assembled condition **3399**, extends from an upper end **3300***a* to a lower end **3300***b* and rotates about an axis of rotation R", similar to the axis of rotation R' of the two-piece rotary knife blade **2300**. The blade carrier portion **3302** includes an inner wall **3304** and an outer wall **3306**, radially spaced apart by a central wall **3316**. The carrier portion **3302** extends axially between a first end or top surface **3308**, defining the upper end **3300***a* of the knife blade **3300**, and a second end or bottom surface **3310**. The carrier portion includes an upper region **3311**, adjacent the top surface **3308** and a lower region **3312**, adjacent the bottom surface **3310**.

As can best be seen in FIG. **76**, in the upper region **3311** of the carrier portion **3302**, a generally cylindrical portion **3340** of the carrier portion outer wall **3306** includes a bearing surface **3319**. The bearing surface **3319**, similar to the bearing surface **2319** of the two-piece rotary knife blade **2300**, functions as the bearing surface for the rotary knife blade **3300** and defines a rotational plane RP" of the blade **3300**. In the lower region **3312** of the carrier portion, a stepped portion **3331** of the outer wall **3306** defines a driven gear **3328** including a plurality of gear teeth **3332**, similar to the gear teeth **2332** of the two-piece rotary knife blade **2300**. The inner wall **3304** of the carrier portion **3302** includes a frustoconical portion **3315** that serves as a nesting or support surface for an outer wall **3354** of the blade portion **3350**.

The blade portion **3350** of the two-piece blade **3300** includes an inner wall **3352** and the outer wall **3354**, the inner and outer walls **3352**, **3354** radially spaced apart by a central wall **3356**. The blade portion **3350** extends between a first end or upper wall **3365** and a second or lower end or wall **3366**. The lower end **3366** of the blade portion **3350** defines a cutting edge **3368** of the blade **3300** and further defines the lower end **3300*b*** of the knife blade **3300**. The inner are outer walls **3352**, **3354** of the blade portion **3350** are generally parallel and frustoconical, converging in a direction proceeding toward the lower end **3300*b*** of the knife blade **3300** and generally centered about the blade axis of rotation R". As can best be seen in FIG. **76**, when the rotary knife blade **3300** is in the assembled condition **3399**, an upper region **3364** of the blade portion **3350** is received and supported in nested relationship in the carrier portion **3302**. An area of contact **3369** between the outer wall **3354** of the blade portion **3350** and the inner wall **3304** of the carrier portion **3302** is generally frustoconical, extending both axially and radially and converging in a direction proceeding toward the lower end **3366** of the blade portion **3350**.

The attachment structure **3370** of the two-piece rotary knife blade **3300** includes mating, releasable securement elements on both the blade portion **3350** and the carrier portion **3302**. In one exemplary embodiment, the attachment structure **3370** includes a plurality of projections **3372** extending radially outwardly from an outer wall **3354** of the blade portion **3350** and a plurality of sockets **3274** formed in an inner wall **3304** of the carrier portion **3302**. In one exemplary embodiment, the number of projections **3372** and sockets **3374** is six.

As best seen in FIG. **79**, each of the projections **3372** of the blade portion **3350** is cantilevered and generally S-shaped and includes: a) an arcuate base portion **3391** that extends radially away from a general extent OWE of the outer wall **3354** of the blade portion; b) an extending middle portion **3392** that extends generally parallel to the general extent OWE of the outer wall **3354**; and c) a generally planar end wall **3390** that is generally orthogonal to the middle portion **3392** and the general extent OWE of the outer wall **3354**.

The configuration of the plurality of projections **3372** and, specifically, the configuration of the middle portion **3392** that extends generally parallel to the outer wall **3354** of the blade portion **3350** provides for increased strength and rigidity of the projections **3372** along a bearing line of action parallel to the general extent OWE of the outer wall **3354**. That is, compared to, for example, the angled projection **2372** (FIG. **73**) of the two-piece rotary knife blade **2300**, the S-shaped configuration of the plurality of projections **3372** of the two-part rotary knife blade **3300** provides for greater strength and rigidity of the projections **3372** as the projections **3372** bear against and ride along a camming surface **3379** of the sockets **3374** when the blade portion **3350** is rotated in a clockwise direction CW with respect to the carrier portion **3302** to move the rotary knife blade **3300** from an unassembled condition **3398** (FIGS. **77** and **78**) to an assembled condition **3399** (FIGS. **74-76**).

The attachment structure **3370** of the two-piece rotary knife blade **3300** further includes the plurality sockets **3374** formed in the inner wall **3304** and extending into the central wall **3316** of the carrier portion **3302**. Each socket **3374** is located in the lower region **3312** of the carrier portion **3302** and includes a first, wider opening region **3376**, a second, tapering region **3378**, and a third, locking region **3380**. The first, wider opening region **3376** includes an upper surface **3376*a***, defining an opening region **3376*c*** (FIG. **77**) of the socket **3374**, and a lower surface **3376*b*** spaced from the upper surface along the inner wall **3304**. The second, tapering region **3378** includes an upper surface **3378*a*** and a lower surface **3378*b***. The third, locking region **3380** includes an upper surface **3380*a*** and a lower surface **3380*b***. The upper surfaces **3378*a***, **3380*a*** of the tapering and locking regions **3378**, **3380** define the camming surface **3379**. The camming surface **3379** proceeds generally toward or converges toward the lower surfaces **3378*b***, **3380*b*** thereby reducing the spacing between the respective upper and lower surfaces, as measured along the inner wall **3304** of the carrier portion **3302**, in moving from the first, opening region **3376** through the second, tapering region **3378** to the third, locking region **3380**. Each of the sockets **3374** comprises a recess **3374*a*** extending radially into the inner wall **3304** of the carrier portion **3302**, the recess **3374*a*** having a longitudinal extent RLE' (FIG. **77**) that is substantially parallel to the first and second ends **3308**, **3310** of the carrier portion **3302**.

To secure the blade portion **3350** to the carrier portion **3302**, the blade portion **3350** is positioned above the carrier portion **3302**. The blade portion **3350** is moved in the downward direction DW" (FIG. **76**) with respect to the carrier portion **3302**. The blade portion **3350** is aligned and rotated with respect to the carrier portion **3302** such that each projection **3372** is received into a respective projection receiving opening **3376*c*** defined by the upper surface **3376*b*** of the first, wider opening region **3376** of its respective mating socket **3374**. Next, after proper alignment, to secure the blade portion **3350** to the carrier portion **3302**, the blade portion **3350** is rotated with respect to the carrier portion **3302** in a clockwise direction of rotation CW (when viewed from above) to the locked position wherein the knife blade **3300** is in the assembled condition **3399**. As the blade portion **3350** is rotated with respect to the carrier portion **3302**, each of the projections of the plurality of projections **3372** moves along the camming surface **3379** and along a locking path of travel LPT' (FIG. **77**) within a respective socket of the plurality of sockets **3374**.

As a given projection **3372** moves along the locking path of travel LPT' in a socket **3374** from the first, wider opening region **3376** to the third, narrow locking region **3380**, the projection **3372** is axially displaced by the camming surface **3379** (defined by the upper surfaces **3378*a***, **3380*a*** of the tapering and locking regions **3378**, **3380**) such that the outer wall **3354** of the blade portion **3350** and the inner wall **3304** of the carrier portion **3302** are urged axially toward each other and the blade portion **3350** is secured to the carrier portion **3302**. FIGS. **79-81** schematically illustrate, in section view, movement of a representative projection **3372** within a socket **3374** along the locking path of travel LPT' from the first, wider opening region **3376** (shown in FIG. **79**—unlocked position), to the second, tapering region **3378** (shown in FIG. **80**—partially locked position), to the third, locking region **3380** (shown in FIG. **81**—locked position—assembled condition). As can be seen in the progression of FIGS. **79-81**, as the twist and lock securement of the blade portion **3350** to the carrier portion **3302** occurs, the blade portion **3350** is urged axially to full engagement with the carrier portion **3302** in the nesting configuration depicted in FIG. **76**.

As can best be seen in FIGS. **80** and **81**, as the blade portion **3350** is twisted in the clockwise direction CW with respect to the carrier portion **3302**, as viewed from above, the generally planar end wall **3390** of each of the plurality of projections **3372** bears against and rides along the camming surface **3379** in the second, tapering region **3378** and third, locking region **3380** of the respective sockets **3374**. As the end wall **3390** of the projections **3372** ride along the camming surface **3379**, the blade portion **3350** is urged in the downward axial direction DW" (FIG. **76**) into a nested configuration with the carrier portion **3302**, that is, the locked position or the assembled condition **3399**.

Two-Piece Rotary Knife Blade **4300**

Turning to FIGS. **82-90**, the two-piece rotary knife blade **4300** includes the carrier portion **4302** and the blade portion **4350**. The knife blade **4300** is schematically shown in assembled condition **4399** in FIGS. **82-85** and in unassembled condition **4398** in FIGS. **86** and **87**. The knife blade **4300**, in assembled condition **4399**, extends from an upper end **4300***a* to a lower end **4300***b* and rotates about an axis of rotation R''', similar to the axis of rotation R' of the two-piece rotary knife blade **2300**. The blade carrier portion **4302** includes an inner wall **4304** and an outer wall **4306**, radially spaced apart by a central wall **4316**. The carrier portion **4302** extends axially between a first end or top surface **4308**, defining the upper end **4300***a* of the knife blade **4300**, and a second end or bottom surface **4310**. The carrier portion includes an upper region **4311**, adjacent the top surface **4308** and a lower region **4312**, adjacent the bottom surface **4310**.

As can best be seen in FIG. **85**, in the upper region **4311** of the carrier portion **4302**, a generally cylindrical portion **4340** of the carrier portion outer wall **4306** includes a bearing surface **4319**. The bearing surface **4319**, similar to the bearing surface **2319** of the two-piece rotary knife blade **2300**, functions as the bearing surface for the rotary knife blade **4300** and defines a rotational plane RP''' of the blade **4300**. In the lower region **4312** of the carrier portion, a stepped portion **4331** of the outer wall **4306** defines a driven gear **4328** including a plurality of gear teeth **4332**, similar to the gear teeth **2332** of the two-piece rotary knife blade **2300**. The inner wall **4304** of the carrier portion **4302** includes a frustoconical portion **4315** which is adjacent and extending upwardly from the bottom surface **4310** of the carrier portion **4302**. The frustoconical portion **4315** serves as a nesting or support surface for an outer wall **4354** of the blade portion **4350**.

The blade portion **4350** of the two-piece blade **4300** includes an inner wall **4352** and the outer wall **4354**, the inner and outer walls **4352**, **4354** radially spaced apart by a central wall **4356**. The blade portion **4350** extends between a first end or upper wall **4365** and a second or lower end or wall **4366**. The lower end **4366** of the blade portion **4350** defines a cutting edge **4368** of the blade **4300** and further defines the lower end **4300***b* of the knife blade **4300**. The blade portion includes an upper region **4357** and a lower region **4358**, the upper and lower regions **4357**, **4358** separated by a slight discontinuity or knee **4359** that extends orthogonally across the blade portion **4350**, generally orthogonal to the axis of rotation R''' and generally parallel to the rotational plane RP''' of the rotary knife blade **4300**. The inner are outer walls **4352**, **4354** of the blade portion **4350** are generally parallel and frustoconical, converging in a direction proceeding toward the lower end **4300***b* of the knife blade **4300** and generally centered about the blade axis of rotation R'''. As can best be seen in FIG. **85**, when the rotary knife blade **4300** is in the assembled condition **4399**, an upper region **4364** of the blade portion **4350** is received and supported in nested relationship in the carrier portion **4302**. An area of contact **4369** between the outer wall **4354** of the blade portion **4350** and the inner wall **4304** of the carrier portion **4302** is generally frustoconical, extending both axially and radially and converging in a direction proceeding toward the lower end **4366** of the blade portion **4350**.

The attachment structure **4370** of the two-piece rotary knife blade **4300** includes mating, releasable securement elements on both the blade portion **4350** and the carrier portion **4302**. In one exemplary embodiment, the attachment structure **4370** includes a plurality of projections **4372** extending radially inwardly from an inner wall **4304** of the carrier portion **4302** and a plurality of sockets **4374** formed in the central wall **4356** of the blade portion **4350**. That is, as best seen in FIG. **84**, each of the plurality of sockets **4374** pass completely through the blade portion **4350** passing from the inner wall **4352** through the outer wall **4354**, defining an opening or a pass through the blade portion **4350**. In one exemplary embodiment, the number of projections **4372** and sockets **4374** is six.

As best seen in FIG. **88**, each of the projections **4372** of the carrier portion **4302** is generally cylindrically shaped and includes: a) a cylinder **4394** extending radially and generally orthogonally away from a general extent IWE of the inner wall **4304** of a lower region **4312** of the carrier portion; and b) a cylindrical outer wall **4395** defined by the cylinder **4394**. As can be seen in FIG. **88**, when the two-piece rotary knife blade **4300** is in the assembled condition **4399**, the cylinders **4394** of the projections **4372** also extend through the sockets **4372** and extend generally orthogonally to a general extent OWE' of the outer wall **4354** of the blade portion **4350**. The plurality of projections **4372** may be, for example, spot welded to the inner wall **4304** of the carrier portion **4302**.

The attachment structure **4370** of the two-piece rotary knife blade **4300** further includes the plurality sockets **4374** extending through the central wall **4356** of the blade portion **4350**. Each socket **4374** is located in the upper region **4357** of the blade portion **4350** and includes a first, wider opening region **4376**, a second, tapering region **4378**, and a third, locking region **4380**. The first, wider opening region **4376** includes an upper surface **4376***a* and a lower surface **4376***b* space from the upper surface along the inner and outer walls **4304**, **4306**. The lower surface **4376***b* defines an opening region **4376***c* of the socket **4372**. The second, tapering region **4378** includes an upper surface **4378***a* and a lower surface **4378***b*. The third, locking region **4380** includes an upper surface **4380***a* and a lower surface **4380***b*. The lower surfaces **4378***b*, **4380***b* of the tapering and locking regions **4378**, **4380** define a camming surface **4379**. The cylindrical wall **4395** of the cylinders **4394** defining the projections **4372** of the carrier portion **4302** ride along and bear against the camming surface **4379** of the sockets **4374** when the blade portion **4350** is rotated in a clockwise direction CW with respect to the carrier portion **4302** to move the rotary knife blade **4300** from an unassembled condition **4398** (FIGS. **86** and **87**) to an assembled condition **4399** (FIGS. **82-85**).

The camming surface **4379** proceeds generally toward or converges toward the upper surfaces **4378***a*, **4380***a* thereby reducing the spacing between the respective upper and lower surfaces, as measured along the outer wall **4354** of the blade portion **4350**, in moving from the first, opening region **4376** through the second, tapering region **4378** to the third, locking region **4380**. Each of the sockets **4374** comprises an opening **4374***a* extending radially through the inner and outer walls **4352**, **4354** of the blade portion **4350**, the opening **4374***a* having a longitudinal extent RLE" (FIG. **87**) that is substantially parallel to the first and second ends **4365**, **4366** of the blade portion **4350**. In one exemplary embodiment, the camming surface **4379** is ratcheted **4379***a*, that is, includes a plurality of rounded, L-shaped projections (FIG. **84**) for a locking effect. When the blade portion **4350** is rotated or twisted with respect to the carrier portion **4302** in the clockwise direction CW, to move the rotary knife blade **4300** to the assembled condition **4399**, the ratcheting **4379***a* of the camming surface **4379** allows movement of the blade portion **4350** with respect to the carrier portion **4302**. However, the ratcheting inhibits movement of the cylinder walls **4395** along the camming surface **4379** of the sockets **4374** in the counterclockwise direction CCW thereby mitigating any tendency of the blade portion **4350** to untwist or rotate in the counterclockwise direction CCW during assembly of the blade portion **4350** and the carrier portion **4302** or during operation of the rotary knife blade **4300** in a power operated rotary knife, such as the power operated rotary knife **100**.

To secure the blade portion **4350** to the carrier portion **4302**, the blade portion **4350** is positioned above the carrier portion **4302**. The blade portion **4350** is moved in the downward direction DW" (FIG. **85**) with respect to the carrier portion **4302**. The blade portion **4350** is aligned and rotated with respect to the carrier portion **4302** such that each projection **4372** is received into a respective projection receiving opening **4376***c* defined by the upper surface **4376***b* of the first, wider opening region **4376** of its respective mating socket **4374**. A length of the cylinders **4394** defining the projections **4372** are configured such that the cylinders **4394***a* are sized to fit into the openings **4376***c* of the sockets **4374** and, as can best be seen in FIG. **88**, are of sufficient length to extend completely though the central wall **4356** of the blade portion **4350** and just a bit beyond the inner wall **4352** of the blade portion **4350**. Next, after proper alignment, to secure the blade portion **4350** to the carrier portion **4302**, the blade portion **4350** is rotated with respect to the carrier portion **4302** in a clockwise direction of rotation CW (when viewed from above) to the locked position wherein the knife blade **4300** is in the assembled condition **4399**. As the blade portion **4350** is rotated with respect to the carrier portion **4302**, each of the projections of the plurality of projections **4372** moves along the camming surface **4379** and along a locking path of travel LPT" (FIG. **86**) within a respective socket of the plurality of sockets **4374**.

As a given projection **4372** moves along the locking path of travel LPT" in a socket **4374** from the first, wider opening region **4376** to the third, narrow locking region **4380**, the projection **4372** is axially displaced by the camming surface **4379** (defined by the lower surfaces **4378***b*, **4380***b* of the tapering and locking regions **4378**, **4380**) such that the outer wall **4354** in the upper region **4357** of the blade portion **4350** and the inner wall **4304** of the carrier portion **4302** are urged axially toward each other and the blade portion **4350** is secured to the carrier portion **4302**. FIGS. **88-90** schematically illustrate, in section view, movement of a representative cylindrical projection **4372** within a socket **4374** along the locking path of travel LPT" from the first, wider opening region **4376** (shown in FIG. **88**—unlocked position), to the second, tapering region **4378** (shown in FIG. **89**—partially locked position), to the third, locking region **4380** (shown in FIG. **90**—locked position—assembled condition). As can be seen in the progression of FIGS. **88-90**, as the twist and lock securement of the blade portion **4350** to the carrier portion **4302** occurs, the blade portion **4350** is urged axially to full engagement with the carrier portion **4302** in the nesting configuration depicted in FIG. **85**.

As can best be seen in FIGS. **89** and **90**, as the blade portion **4350** is rotated or twisted in the clockwise direction CW with respect to the carrier portion **4302**, the generally cylindrical wall **4395** of each of the plurality of projections **4372** bears against and rides along the camming surface **4379** in the second, tapering region **4378** and third, locking region **4380** of the respective sockets **4374**. As the cylindrical wall **4395** of the projections **4374** ride along the camming surface **4379**, the blade portion **4350** is urged in the downward axial direction DW''' (FIG. **85**) into a nested configuration with the carrier portion **4302**, that is, the locked position or the assembled condition **4399**.

Two-Piece Rotary Knife Blade **5300**

Turning to FIGS. **90-99**, the two-piece rotary knife blade **5300** includes the carrier portion **5302** and the blade portion **5350**. The rotary knife blade **5300** is schematically shown in assembled condition **5399** in FIGS. **91-93** and in unassembled condition **5398** in FIGS. **94** and **95**. The blade **5300**, in assembled condition **5399**, extends from an upper end **5300***a* to a lower end **5300***b* and rotates about an axis of rotation R'''', similar to the axis of rotation R' of the two-piece rotary knife blade **2300**. The blade carrier portion **5302** includes an inner wall **5304** and an outer wall **5306**, radially spaced apart by a central wall **5316**. The carrier portion **5302** extends axially between a first end or top surface **5308**, defining the upper end **5300***a* of the knife blade **5300**, and a second end or bottom surface **5310**. The carrier portion includes an upper region **5311**, adjacent the top surface **5308** and a lower region **5312**, adjacent the bottom surface **5310**.

As can best be seen in FIG. **93**, in the upper region **5311** of the carrier portion **5302**, a generally cylindrical portion **5340** of the carrier portion outer wall **5306** includes a bearing surface **5319**. The bearing surface **5319**, similar to the bearing surface **2319** of the two-piece rotary knife blade **2300**, functions as the bearing surface for the rotary knife blade **5300** and defines a rotational plane RP'''' of the blade **5300**. In the lower region **5312** of the carrier portion, a stepped portion **5331** of the outer wall **5306** defines a driven gear **5328** including a plurality of gear teeth **5332**, similar to the gear teeth **2332** of the two-piece rotary knife blade **2300**. The inner wall **5304** of the carrier portion **5302** includes a frustoconical portion **5315** that serves as a nesting or support surface for an outer wall **5354** of the blade portion **5350**.

The blade portion **5350** of the two-piece blade **5300** includes an inner wall **5352** and the outer wall **5354** radially spaced apart by a central wall **5356**. The blade portion **5350** extends between a first end or upper wall **5365** and a second or lower end or wall **5366**. The lower end **5366** of the blade portion **5350** defines a cutting edge of the rotary knife blade **5300** and also defines the lower end **5300***b* of the blade **5300**. In one exemplary embodiment, the inner and outer walls **5352**, **5354** are substantially parallel and frustoconical in configuration, converging in a direction proceeding toward the lower end **5300***b* of the knife blade **5300** and generally centered about the blade axis of rotation R''''. As can best be seen in FIG. **93**, when the rotary knife blade **5300** is in the assembled condition **5399**, an upper region **5364** of the blade portion **5350** is received and supported in nested relationship in the carrier portion **5302**. An area of contact **5369** between the outer wall **5354** of the blade portion **5350** and the inner wall **5304** of the carrier portion **5302** is generally frustoconical, extending both axially and radially and converging in a direction proceeding toward the lower end **5366** of the blade portion **5350**.

The attachment structure **5370** of the two-piece rotary knife blade **5300** includes mating, releasable securement elements on both the blade portion **5350** and the carrier portion **5302**. In one exemplary embodiment, the attachment structure **5370** includes a plurality of projections **5372** extending radially outwardly from an outer wall **5354** of the blade portion **5350** and a plurality of sockets **5374** formed in the inner wall **5304** of the carrier portion **5302**. In one exemplary embodiment, the number of projections **5372** and sockets **5374** is six.

As best seen in FIG. **97**, each of the projections **5372** of the blade portion **5350** is generally V-shaped and includes: a) an lower rib **5396** that extends radially outwardly in a direction generally parallel to the rotational plane RP"" (FIGS. **93** and **99**) of the blade **5300**; and b) an upper rib **5397** that extends generally orthogonally away from a general extent OWE" of the outer wall **5354** of the blade portion; and c) a generally planar upper or end wall **5397***a* defined by the upper rib **5397** that is also generally orthogonal to the general extent OWE' of the outer wall **5354**. The V-shaped projections **5372** of the blade portion **5350** may be advantageously fabricated as extruded "bumps" formed in the steel stamping comprising the blade portion **5350**.

The configuration of the plurality of projections **5372** and, specifically, the configuration of the lower rib **5396** which supports and reinforces the upper rib **5397** provides for increased strength and rigidity of the projections **5372** along a bearing line of action parallel to the general extent OWE" of the outer wall **5354**. That is, compared to, for example, the angled projections **2372** (FIG. **73**) of the two-piece rotary knife blade **2300**, the V-shaped configuration of the plurality of projections **5372** of the two-part rotary knife blade **5300** provides for greater strength and rigidity of the projections **5372** as the projections **5372** bear against and ride along a camming surface **5379** of the sockets **5374** when the blade portion **5350** is properly aligned and rotated in a clockwise direction CW with respect to the carrier portion **5302** to urge the rotary knife blade **5300** from an unassembled condition **5398** (FIGS. **94** and **95**) to an assembled condition **5399** (FIGS. **91**-**93**).

The attachment structure **5370** of the two-piece rotary knife blade **5300** further includes the plurality sockets **5374** formed in the inner wall **5304** and extending into the central wall **5316** of the carrier portion **5302**. Each socket **5374** is located in the lower region **5312** of the carrier portion **5302** and includes a first, wider opening region **5376**, a second; tapering region **5378**, and a third, locking region **5380**. The first, wider opening region **5376** includes an upper surface **5376***a*, defining an opening region **5376***c* of the socket **5374**, and a lower surface **5376***b* spaced from the upper surface along the inner wall **5304**. The second, tapering region **5378** includes an upper surface **5378***a* and a lower surface **5378***b*. The third, locking region **5380** includes an upper surface **5380***a* and a lower surface **5380***b*. The upper surfaces **5378***a*, **5380***a* of the tapering and locking regions **5378**, **5380** define the camming surface **5379**. The camming surface **5379** proceeds generally toward or converges toward the lower surfaces **5378***b*, **5380***b* thereby reducing the spacing between the respective upper and lower surfaces, as measured along the inner wall **5304** of the carrier portion **5302**, in moving from the first, opening region **5376** through the second, tapering region **5378** to the third, locking region **5380**. Each of the sockets **5374** comprises a recess **5374***a* extending radially into the inner wall **5304** of the carrier portion **5302**, the recess **5374***a* having a longitudinal extent RLE''' (FIG. **94**) that is substantially parallel to the first and second ends **5308**, **5310** of the carrier portion **5302**.

To secure the blade portion **5350** to the carrier portion **5302**, the blade portion **5350** is positioned above the carrier portion **5302**. The blade portion **5350** is moved in the downward direction DW"" (FIG. **93**) with respect to the carrier portion **5302**. The blade portion **5350** is aligned and rotated with respect to the carrier portion **5302** such that each projection **5372** is received into a respective projection receiving opening **5376***c* defined by the upper surface **5376***b* of the first, wider opening region **5376** of its respective mating socket **5374**. Next, after proper alignment, to secure the blade portion **5350** to the carrier portion **5302**, the blade portion **5350** is rotated with respect to the carrier portion **5302** in a clockwise direction of rotation CW (when viewed from above) to the locked position wherein the knife blade **5300** is in the assembled condition **5399**.

As the blade portion **5350** is rotated with respect to the carrier portion **5302**, each of the projections of the plurality of projections **5372** moves along the camming surface **5379** and along a locking path of travel LPT''' (FIG. **94**) within a respective socket of the plurality of sockets **5374**. As a given projection **5372** moves along the locking path of travel LPT''' in a socket **5374** from the first, wider opening region **5376** to the third, narrow locking region **5380**, the projection **5372** is axially displaced by the camming surface **5379** (defined by the upper surfaces **5378***a*, **5380***a* of the tapering and locking regions **5378**, **5380**) such that the outer wall **5354** of the blade portion **5350** and the inner wall **5304** of the carrier portion **5302** are urged axially toward each other and the blade portion **5350** is secured to the carrier portion **5302**. FIGS. **96**-**98** schematically illustrate, in section view, movement of a representative projection **5372** within a socket **5374** along the locking path of travel LPT''' from the first, wider opening region **5376** (shown in FIG. **96**—unlocked position), to the second, tapering region **5378** (shown in FIG. **97**—partially locked position), to the third, locking region **5380** (shown in FIG. **98**—locked position—assembled condition). As can be seen in the progression of FIGS. **96**-**98**, as the twist and lock securement of the blade portion **5350** to the carrier portion **5302** occurs, the blade portion **5350** is urged axially to full engagement with the carrier portion **5302** in the nesting configuration depicted in FIG. **93**.

As can best be seen in FIGS. **97** and **98**, as the blade portion **5350** is rotated in the clockwise direction CW, as viewed from above, with respect to the carrier portion **5302**, the generally planar upper wall **5397***a* of each of the plurality of projections **5372** bears against and rides along the caroming surface **5379** in the second, tapering region **5378** and third, locking region **5380** of the respective sockets **5374**. As the end or upper wall **5397***a* of the projections **5372** ride along the caroming surface **5379**, the blade portion **5350** is urged in the downward axial direction DW''' (FIG. **93**) into a nested configuration with the carrier portion **5302**, that is, the locked position or the assembled condition **5399**. In FIG. **99**, the two-piece rotary knife blade **5300** is schematically shown in section view as mounted in an appropriately configured blade housing **5400** of a power operated rotary knife, such as the power operated rotary knife **100** of the present disclosure.

As used herein, terms of orientation and/or direction such as front, rear, forward, rearward, distal, proximal, distally, proximally, upper, lower, inward, outward, inwardly, outwardly, horizontal, horizontally, vertical, vertically, axial, radial, longitudinal, axially, radially, longitudinally, etc., are provided for convenience purposes and relate generally to the orientation shown in the Figures and/or discussed in the Detailed Description. Such orientation/direction terms are not intended to limit the scope of the present disclosure, this application, and/or the invention or inventions described therein, and/or any of the claims appended hereto. Further, as used herein, the terms comprise, comprises, and comprising are taken to specify the presence of stated features, elements, integers, steps or components, but do not preclude the presence or addition of one or more other features, elements, integers, steps or components.

What have been described above are examples of the present disclosure/invention. It is, of course, not possible to describe every conceivable combination of components, assemblies, or methodologies for purposes of describing the present disclosure/invention, but one of ordinary skill in the art will recognize that many further combinations and permutations of the present disclosure/invention are possible. Accordingly, the present disclosure/invention is intended to embrace all such alterations, modifications, and variations that fall within the spirit and scope of the appended claims.

What is claimed is:

1. An annular rotary knife blade for rotation about an axis of rotation in a power operated rotary knife, the rotary knife blade comprising:

an annular carrier portion including a first end and an axially spaced apart second end, an outer wall and a radially inward spaced apart inner wall extending respectively between the first end and the second end, the carrier portion including a set of gear teeth and a knife blade bearing surface, the carrier portion further including a plurality of projections extending from the inner wall of the carrier portion;

an annular blade portion including a first end and an axially spaced apart second end, an inner wall and a radially spaced apart outer wall, the second end defining a cutting edge of the blade portion, an upper region extending axially from the first end and a lower region extending axially from the second end, and a plurality of sockets extending radially through the inner and outer walls, the plurality of sockets disposed in the upper region of the blade portion and spaced axially from the first end, each of the plurality of sockets having a longitudinal extent that extends substantially parallel to the first end of the blade portion and including a first surface and a spaced apart camming surface and further includes a first, opening region, a second, tapering region, and a third, locking region, the first, opening region defining a projection receiving opening, the camming surface converging toward the first surface when moving from the first, opening region to the third, locking region thereby reducing a spacing between the first surface and the camming surface as measured along the outer wall; and

the blade portion configured to be received in a nested relationship by the carrier portion such that each of the plurality of projections is received into a respective projection receiving opening of the plurality of sockets and, upon rotating the blade portion with respect to the carrier portion in a direction of rotation to a locked position, each of the projections of the plurality of projections moves along a path of travel within a respective socket of the plurality of sockets and is axially displaced by the camming surface of the socket such that the outer wall of the blade portion and the inner wall of the carrier portion are urged toward each other and the blade portion is secured to the carrier portion.

2. The annular rotary knife blade of claim **1** wherein where the first surface is closer to the first end and the camming surface is closer to the second end.

3. The annular rotary knife blade of claim **1** wherein a discontinuity extends between the upper and lower regions.

4. The annular rotary knife blade of claim **3** wherein the discontinuity is substantially parallel to the first end.

5. The annular rotary knife blade of claim **1** wherein the camming surface is ratcheted.

6. The annular rotary knife blade of claim **5** wherein the ratcheted ramming surface comprises a plurality of rounded, L-shaped projections to enhance locking effect.

7. The annular rotary knife blade of claim **1** wherein the plurality of projections comprise radially outwardly extending projections.

8. The annular rotary knife blade of claim **1** wherein the direction rotation of the blade portion with respect to the carrier portion to move to the locked position is opposite in rotational direction to a direction of rotation of the blade in a rotary knife.

9. The annular rotary knife blade of claim **1** wherein a direction of rotation of the blade in a rotary knife is counterclockwise when viewed from the blade central axis axially above the first end of the blade carrier and the direction of rotation of the blade portion with respect to the carrier portion to move to the locked position is clockwise when viewed from the blade central axis axially above the first end of the blade carrier.

10. The annular rotary knife blade of claim **1** wherein the inner and outer walls of the blade portion include substantially frustoconical portions.

11. The annular rotary knife blade of claim **1** wherein the inner and outer walls of the blade portion are substantially frustoconical.

12. An annular blade portion configured to be releasably affixed to an annular carrier portion to form a rotary knife blade for rotation about an axis of rotation of in a power operated rotary knife blade, the annular blade portion comprising:

a first end and an axially spaced apart second end, an inner wall and a radially spaced apart outer wall, the second end defining a cutting edge of the blade portion;

an upper region extending axially from the first end and a lower region extending axially from the second end; and

a plurality of sockets extending radially through the inner and outer walls, the plurality of sockets disposed in the upper region of the blade portion and spaced axially from the first end, each of the plurality of sockets having a longitudinal extent that extends substantially parallel to the first end of the blade portion and including a first surface and a spaced apart camming surface and further includes a first, opening region, a second, tapering region, and a third, locking region, the first, opening region defining a projection receiving opening, the camming surface converging toward the first surface when moving from the first, opening region to the third, locking region thereby reducing a spacing between the first surface and the camming surface as measured along the outer wall.

13. The annular blade portion of claim **12** where the first surface is closer to the first end and the camming surface is closer to the second end.

14. The annular blade portion of claim **12** wherein a discontinuity extends between the upper and lower regions.

15. The annular blade portion of cm **14** wherein the discontinuity is substantially parallel to the first end.

16. The annular blade portion of claim **12** wherein the camming surface is ratcheted.

17. The annular blade portion of claim **16** wherein the ratcheted camming surface comprises a plurality of rounded, L-shaped projections to enhance locking effect.

18. The annular blade portion of claim **12** wherein the inner and outer walls include substantially frustoconical portions.

19. The annular rotary knife blade of claim **12** wherein the inner and outer walls are substantially frustoconical.

* * * * *